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Advances In Offshore Exploration Techniques
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Dr. Charles B. Officer
Guest Editor

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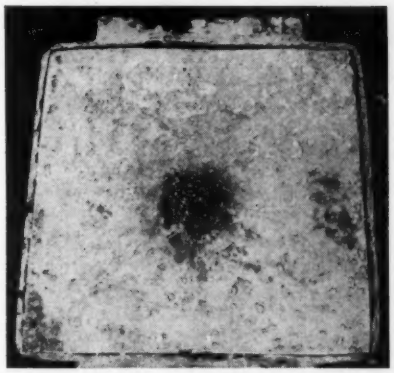
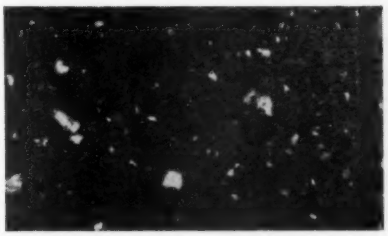


Notice clean, non-shattering perforation in this test block of Strata-Crete 6 cement.



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Way offshore . . .

With the Publisher

I have an old oilfield amigo, W. R. Mahan, now of Ashland, Kentucky, who once closed a valve too fast.

It was on a little wildcat well held cable-tooled in, back in the days when you just set pipe in the hole and didn't cement it. What happened, a string of pipe climbed right out of the hole and set down beside him, lifted out by gas pressure, and he couldn't get his feet in motion but it wouldn't have done any good anyway.

Luckily, the stalk of pipe fell the other way.

Of course, W. R. wasn't much worse shook-up than we were at the idea of rounding-up and writing about the latest advances in offshore petroleum exploration techniques. Luckily, Dr. Charles B. Officer of Marine Geophysical Services Corp. came to our rescue, and kindly agreed to act as editor of this special report, which you'll find in this issue.

So we owe heart-felt thanks to Dr. Officer for coming to our rescue, and can only hope that he'll be instrumental in finding several 100 million barrel fields (which are the best kind).

Speaking of special reports, we'll have another un' coming up for you in May. On submarine pipelining. And it should be a woolly-booger, for Brown Booth of Brown & Root told us today he had a "hairy" story for the issue.

We have this further special report to make, with witnesses to verify its authenticity.

On the way to a writers' shindig, Margaret Birdsong—a fellow editor up in Austin—was asked if she played golf. Her response put everybody in stitches. "Look," she replied, "I don't even know which end of the caddy to grip!"

While you're yukking about that un', we'll sign off and . . .

See you next month!

Long John Latham

Recent Advances In Offshore Petroleum Exploration Techniques

By CHARLES B. OFFICER

Marine Geophysical Services Corp.

Houston, Texas

Messrs. J. H. Latham and J. R. Hadfield of **Offshore** have asked the writer if he would act as editor for a series of contributed papers on recent advances in offshore petroleum exploration techniques. I was pleased to do so and agreed with them that such a series could provide a useful and convenient compilation.

There have been several advances made in offshore exploration technology. To my mind this has been because it is a relatively recent exploration activity and also because it is closely related and can call upon portions of the existing technologies of land petroleum exploration, marine navigation, oceanography, and underwater sound.

Arbitrarily the discussions here have been limited to the developments made over the past three years; it was felt that the techniques developed prior to that time were sufficiently familiar not to be repeated here.

The contributed papers are:

1) "Marine Seep Detection" by H. F. Dunlap and C. A. Hutchinson Jr., Atlantic Refining Co.
2) "New Miniaturized Raydist Equipment for Offshore Oil Exploration" by Joseph T. Bradbury, Hastings-Raydist Inc.
3) "Decca 'Lambda' Surveying System" by Claud Powell, Decca Navigator Co. Ltd.
4) "Three Recent Developments in Marine Geophysics: Gas Exploder, Sparker, and Harru" by Charles B. Officer, Marine Geophysical Services Corp.
5) "New Marine Seismic System" by F. J. McDonal, Socony Mobil Oil Co. Inc.
6) "Versatility Chracterizes Two-Boat Seismic Operations" by Carl H. Savit and Charles S. Sebastian, Western Geophysical Co. of America.

One of the papers discusses a geochemical technique for the direct detection of oil seeps. Three of the papers discuss location systems; two are phase comparison systems, and the other is a radar ranging system. Three of the papers discuss four geophysical systems all of which are seismic reflection in nature; one uses an underwater spark detonation as sound source and gives detailed geological information but is depth limited, two use an explosive mixture of propane and oxygen as sound source and provide reflections from considerably greater depths, and the fourth uses conventional explosives and gives the maximum depth of penetration.

I should like to express my appreciation to the authors of the above papers for their contributions. To the best of my knowledge all the developments made over the past three years which have actually been used for offshore petroleum prospection have been included here.

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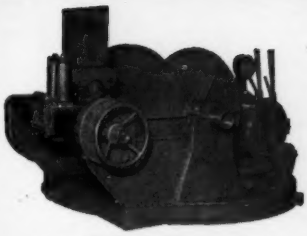

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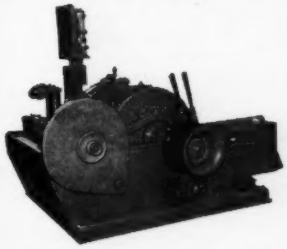

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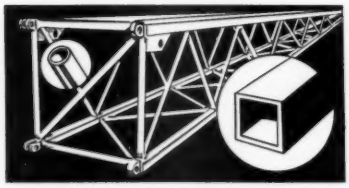

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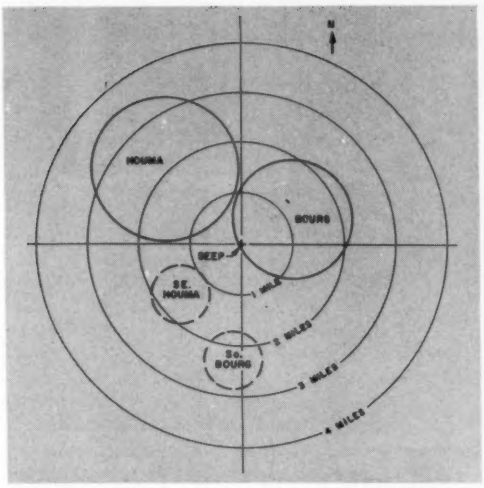

FIGURE 1—Detail map showing relation of Bourg and Houma fields to seep.

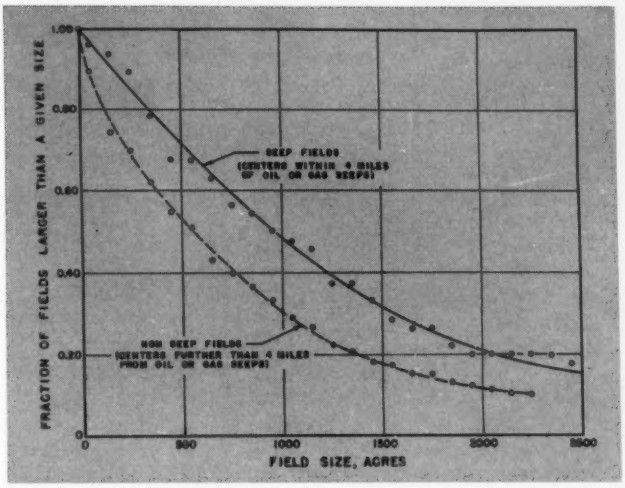

FIGURE 2—Size distribution of fields associated and not associated with seeps.

Special Offshore Report

Marine Seep Detection

By H. F. DUNLAP and C. A. HUTCHINSON, JR.
The Atlantic Refining Company
Dallas, Texas

The Atlantic Refining Company has developed and proven operational an inexpensive and reliable system[1] for detecting gas seeps in water covered areas, and has made the technique available to the industry through license.[2]

The method detects methane dissolved in sea water. Seep bubbles (principally methane) rise from the sea bottom to the surface, dissolving in the water, at least in part, as they rise. The sea water containing the dissolved gas is spread by currents into long plumes stretching away from the seep. The survey vessel, running at right angles to the current direction, samples the sea water continuously. The dissolved gas is broken out of solution and analyzed for methane. The system is sensitive enough to detect seeps several miles from their source.

In normal practice, survey lines are run one mile apart. Seep indications picked up on an initial grid survey are verified by visiting the area again several days later and conducting a detailed search in the area of the initial indication. Unless a seep can be verified by the second visit, it is not reported.

The equipment is relatively simple. It has been mounted on 65-ft. boats for offshore work, and on outboard craft as small as fourteen feet for work in protected waters. The technique is cheap and compares favorably with other minimum cost exploration methods, such as the airborne magnetometer and photogeological methods.

So much for method and instruments. Let us now consider the usefulness of seep information. Most exploration workers would agree that presence of oil and gas seeps is of value in indicating the general petroliferousness of a new basin or a new province. However, there is some difference of opinion as to just how important seep information is in localizing areas of accumulation within the basin.

A few years ago we carried out statistical studies in an attempt to gain further insight on this question.

The results of our study suggest rather strongly that an exploratory well located near an oil or gas seep has a higher chance of finding oil or gas than one which is not so located. Also, other things being equal, the accumulation which the well finds is, on the average, about a third larger than that found by an exploratory well which has no seep associated with it.

Method of analysis . . . W. K. Link[6] has presented data on the significance of oil and gas seeps in world oil exploration. He concludes that seeps of oil or gas are important in a regional sense, and states that most of the important oil producing regions of the world were detected or discovered by surface oil or gas seeps. However, the question of just how valuable a seep is in localizing an area of accumulation is not resolved by his discussion, although several examples are quoted in which wells located on or near seeps did find important oil pools. In order to answer this question rigorously in a given area, the location of all the seeps in the area together with all the oil accumulations in the area would have to be known. We could then state with confidence that a certain fraction of the seeps overlie oil or gas fields.

Obviously, information as complete as this will never be available. However, if the location of only a fraction, say 1/2 or 1/4 of all the seeps and fields is known, we would still be able to estimate with fair accuracy the fraction of seeps which overlie oil accumulations, provided that these known seeps and fields constitute random samples; that is, provided they are representative of all the seeps and fields in the area. In most oil provinces gealogists believe that all of the oil and gas fields have *not* yet been found. Also, some of the known seeps have not been tested by deep wells. In view of this, the percentage of seeps which overlie known fields determined in this way will be smaller than actual percentage of seeps which overlie present and future production. In what follows, we will study the correlation of known seeps (those given by Link for South Louisiana, which we assume to be a random sample) with known oil and gas fields. The true correlation between seeps and production should be stronger than is indicated by this study for the reasons noted above.

The study was carried out in the following manner. Link's seep map for South Louisiana shows the location of 51 oil and gas seeps. A photographic enlargement of Link's map was made to the same scale as a map showing oil field location, and the seep locations given by Link were transferred to this map. The distance from each seep to all fields whose centers were less than four miles away from the seep was then measured with dividers. The productive area of each field was obtained from sources such as the Statistical Volumes published by the A. I. M. E., the yearbooks of the National Oil Scouts' and Landmen's Association, and the January (statistical) issues of the *Oil and Gas Journal*. A detail map of the vicinity of each seep was prepared, using polar coordinate paper, with

the seep shown at the center. The productive areas of all fields whose centers were less than four miles from the seep were then shown on the detail map at the proper distance from the seep, assuming that the field area was circular. This assumption of a circular field area is an obvious simplification; but when a large number of cases are considered, the errors should compensate. *Fig.* 1 is an example of one of these detail maps. The two fields shown dotted on this figure have been discovered since this study was made.

Relation of seeps to production . . . After similar detail maps had been prepared for all seeps, the number of times that a seep occurred directly over a productive area was noted. This was true for 9* of the 51 seeps, and the ratio 9/51 gives at once the chance of success for exploratory wells located on these 51 seeps. This chance of success is 17 per cent, which is about the same as the 15 per cent chance of success reported for Louisiana wildcats located by geology and/or geophysics.

Link's map shows the seeps as squares or triangles which are about four miles on a side. In the work described above, the centers of the squares or triangles were taken to be the seep locations. It is obvious, however, that the actual location of the seeps might be as much as two miles from these centers. This uncertainty is undesirable; but if a large number of seeps and fields are used, the *average* location of the seeps *will* be at the center of the figures, and the statistics should be valid. In other words, some of the individual cases where this study indicates that seeps overlie production may be incorrect; but other seeps which are shown not to overlie production probably do, so that the errors tend to compensate.

A question can be raised concerning these data. If the correlation of seeps with producing areas is striking primarily because the "producing" seeps are associated with heavily faulted piercement salt domes, then the correlation is of academic interest only. This is because all or nearly all of the piercement salt domes on the Louisiana Gulf Coast have already been found, and piercement salt domes are not a common feature of other exploration provinces.

Actually, the correlation of seeps with production is very high regardless of whether or not a seep is also associated with a piercement salt dome. Of the 51 seeps shown on Link's map, 31 are not associated with piercement salt domes. Of these, 5 seeps directly overlie production (Welch, St. Martinville, Bourg, Lockport and Jeanerette). Thus, 16 per cent of these 31 seeps not associated with piercement salt domes are known to be underlain by oil today. It is possible that other fields may be found under some of these seeps. The remaining 20 seeps *are* associated with piercement salt domes; and of these, four seeps directly overlie production (Pine Bluff, Lake Washington, Section 28 and Anse La Butte). The chance of success is 20 percent for wells drilled on these seeps. The difference is probably not significant, particularly in view of the fact that some seeps not associated with salt domes have never been tested by any deep drilling, while almost all salt domes in South Louisiana have had many deep tests.

These results become more meaningful when compared with the recent wildcat success record of the industry. For 1958 and 1959, technically located (geology, geophysics, or both) exploratory wells were successful about 15 percent of the time in Louisiana. Apparently, drilling near a seep would result in as high a chance of success as drilling seismic and subsurface prospects! Wells located by geology and/or geophysics which are *also* near a seep should have the highest chance of success of all.

Relation of seeps to field size . . . During the course of the study, the distribution of sizes (productive area) of fields whose centers are less than four miles from seeps was determined and compared to the size distribution of fields not closely associated with seeps. *Fig.* 2 gives this size distribution for both "seep" and "non-seep" fields. It is evident from this plot that the "seep" fields are, in general, larger than the "non-seep" fields. One measure of this relation is given by the ratio of the average seep field area (1267 acres) to the average non-seep field area (980 acres). This ratio equals 1.3, with a probable error of $\pm .13$.

Although it would be expected that producible reserves, which are actually the quantity of interest, would be roughly proportional to field size in a given geologic province, an attempt was made to check this point. Data on field reserves are much scarcer than data on field areas; however, some information was obtained from the January (statistical) issues of the *Oil and Gas Journal*. This source gives total quantity of oil produced from various fields, and gives estimates of the quantity of remaining producible oil. The sum of these two was obtained for 16 fields in South Louisiana whose centers lie within four miles of a seep, and for 80 fields whose centers lie more than four miles from a seep. The total reserves of the "seep" fields averaged 53 million barrels, compared to 40 million barrels for the "non-seep" fields, so that the ratio of the average producible oil associated with the two classes of fields was $53/40 = 1.3$. This is just what was found for the ratio of average areas.

The data reviewed thus far have indicated that an exploratory well located over a seep in South Louisiana will have a 17 percent chance of finding production. Also, fields found within four miles of seeps will be a third larger than fields which are more than four miles from seeps.

Possible explanations . . . These conclusions would be more acceptable if some explanation for them were available. The following speculations are offered for whatever they may be worth.

We believe that most geologists will agree that oil accumulations are quite commonly associated with faults. These faults may result from local uplift, or the fault may itself form the trap without apparent anticlinal structure being present. It is further assumed that this system of faults sometimes extends, either directly or indirectly, from the major zone of accumulation to the surface, and thus sometimes provides leakage paths for the oil or gas through the fault zone. Sometimes the major zone of accumulation is not connected to the surface directly or indirectly by faulting. However, the system of faults and fractures may provide leakage paths to the surface from smaller, perhaps noncommercial accumulations, which overlie the major accumulation at depth. Fracture zones are frequently not vertical; however, it might be noted that a fracture which extends to 10,000 feet with a dip of 60° would result in a horizontal displacement of only about a mile; whereas, the average field diameter is about a mile and a half. In the Gulf Coast, high angle faulting is the rule rather than the exception, and faults with dips of 60° or greater are common.

Finally, it appears reasonable that the larger the accumulation of oil or gas, the greater is the likelihood that it will be leaking through faults or fractures in the overlying rock at one or more places. In a large field, several seeps are likely to be present, and there is a much better chance that at least one of these will be found. This may account for the correlation of seeps with the larger fields.

Conclusions . . . The occurrence of oil and gas seeps should be given considerable weight in evaluating a prospective exploratory drilling location. Both the chance of success and the stakes are increased if a seep is present. While South Louisiana data were used for this study, we believe that similar conclusions would be valid for many other sedimentary basins, as well.

In the case of prospects covered by water, the marine seep detector offers an effective and inexpensive method of locating these seeps. A combination survey in which the Sonoprobe, sparker, or gas-gun seismic technique is used simultaneously with the seep detector on a single boat would appear to offer great promise as a system for localizing areas of interest at minimum cost.

*Welch, St. Martinville, Bourg, Lockport, Jeanerette, Pine Bluff, Lake Washington, Section 28, and Anse La Butte fields.

THE AUTHORS

H. F. Dunlap received a Ph.D. in physics from Rice Institute in 1941. He joined Atlantic Refining Company's Research and Development Department in 1945, and until February of 1959 was head of the Exploration Research Section. He is presently head of the Exploitation Research Section, and is a member of SEG, AIME, AAPG and the American Physical Society.

C. A. Hutchinson, Jr. attended the University of Colorado, receiving a B.S. and M.S. in chemical engineering, and a B.S. in electrical engineering during 1944-49. He joined Atlantic's Research and Development Department in January, 1949, where he has had experience in reservoir mathematics, operations research and reservoir mechanics. He is presently reservoir engineering supervisor in the Crude Oil Production Department. He is a member of AIME, API and AIChE.

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FIGURE 4—Shipboard position indicator or "Navigator" unit on small survey boat. Each of the two indicator dials furnishes a direct reading of distance from boat to its corresponding shore station. At right is automatic position recorder which provides a continuous permanent record of the ship's position.

FIGURE 6—Typical plug-in type module. If any component failure should occur, entire module is replaced simply by plugging in a spare.

Special Offshore Report

New Miniaturized Raydist Equipment For Offshore Oil Exploration

By JOSEPH T. BRADBURY
Hastings-Raydist, Inc.
Hampton, Virginia

Keeping pace with the expansion in worldwide exploration for oil has been the advancement in the field of electronic position location equipment for survey parties as exemplified by the introduction of the Miniaturized Raydist DM System. This newly developed direct distance measuring system automatically determines and records a geophysical survey boat's position at all times with accuracies heretofore unobtainable. The newest transistorized models of the Raydist DM System are undoubtedly the world's smallest precision equipment for accurately determining distance and position.

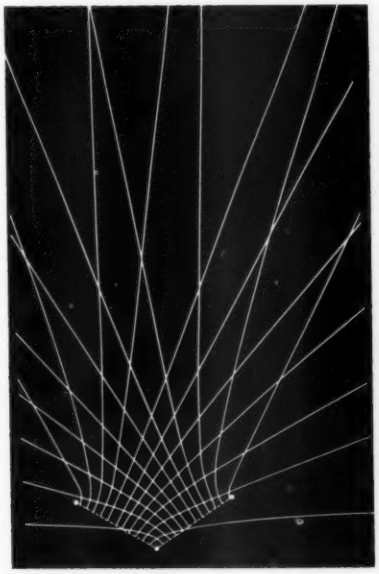


FIGURE 1—Intersection pattern of lines of position in typical hyperbolic system. Note decrease in precision with increase in range.

Since the earliest days of offshore oil exploration, there has been a need for accurate automatic position determination. This requirement extends from the original exploratory survey to the actual drilling, and the need becomes more and more critical as operations are extended farther and farther from shore.

In the early days of offshore work after the war, the positioning problem was solved by adopting certain wartime developed navigation equipment. Although the equipment satisfied a need at the time, it was far from the ideal solution. Some of the equipment operated on the higher radio frequencies which required line-of-sight between vessel and shore stations. To achieve maximum ranges, large towers were required to elevate the antennas. Even this solution became impossible as the operating ranges were extended.

The first radio positioning system developed specifically for hydrography and offshort oil exploration, was the Raydist Type N System. As long ago as 1952, the first of a series of these hyperbolic systems was installed in the Gulf area to provide positioning service to the oil industry. This system was far superior to the high frequency systems then in use since it provided coverage out to well beyond 100 miles without specially designed antennas, and continuous accurate position data as well as a permanent record of the exact position of the vessel. Accuracies of a few feet were demonstrated regularly with this new system and the permanent record of the "track" of the vessel was of considerable importance to the users since it made it possible to verify the survey results at any later date if found to be necessary or advisable.

These early Raydist Systems found worldwide acceptance in the few years after their introduction, but like all developments in the oil industry, new designs became necessary to meet the changing requirements of the industry. The well established networks in the Gulf area continued to serve the industry satisfactorily. There was a growing demand, however, for small lightweight equipment which

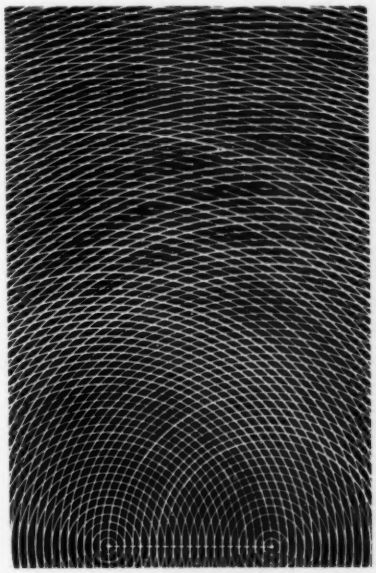


FIGURE 2—Corresponding intersection in pattern for Type DM Raydist Range System.

could be moved rapidly from point to point. There were also definite objections to hyperbolic systems. Although they served well where established, the problems of the preparation of special hyperbolic charts, the necessity for the use of three or more shore sites, and the deterioration of accuracy at long ranges generally limited their application.

Major breakthrough . . . The first major breakthrough occurred when the Type DM Raydist System was developed. This system, operating on the same proven methods of phase comparison and still utilizing the lower frequencies, offered an interim solution to the rapid installation and removal problem. It gave position in terms of direct distance measurements from only two shore stations. Operating range of the DM System was the same as the older Type N Raydist, but there was one very notable difference.

The accuracy of the new system was markedly superior to the hyperbolic system at the greater ranges. A typical hyperbolic pattern is shown in *Fig.* 1. The three foci of the hyperbolic system (two separate and one common) represent the location of the shore stations. The accuracy of a position fix in any area is determined by the spacing between adjacent position lines and the intersection angle between lines. The more favorable the angle and the closer the spacing, the more precise the fix. It is obvious that the fix with a hyperbolic system can become quite weak as the distance from the shore stations increases. *Fig.* 2 shows the equivalent circular pattern from a Raydist DM System. Here the position lines are circles drawn around the two fixed stations. Again the accuracy of a fix is based upon the line spacing and the angle of intersection, but with the Raydist DM System the accuracy is much greater over a far greater area than is possible with an equivalent hyperbolic system.

Economic advantages . . . In addition, the Raydist DM System offers other advantages which represent appreciable savings to the oil industry. The preparation of charts is no longer the tedious, complex and expensive affair it once was with the hyperbolic systems. Charts with the DM System are merely circular arcs drawn around the two shore stations. They can be prepared rapidly and easily and calculations of position are no longer the difficult problem they once were. This factor alone can effect appreciable savings for the user. Further savings are realized by the fact that only two shore stations are required instead of the three or more required for hyperbolic systems.

With the Raydist DM System, new avenues were opened in the exploration field. A survey no longer required the installation of a complete navigational facility and chart preparation. The Raydist DM System made it possible to install and operate in an area with a minimum outlay of funds and effort.

Transistorization . . . The last two years saw still another breakthrough in the positioning field. The technology of transistorization was making rapid advances in the communications field, and it was only natural that these developments were extended towards making the DM Raydist system even more portable and more versatile than ever before. The use of transistors brings with it three major advantages. Transistors are far smaller than their equivalent vacuum tubes, making it possible to put more electronic units in a given space with less weight. Secondly, they do not require the use of a heated cathode or filament so that they can operate far more efficiently and can utilize batteries which need only have a fraction of the capacity of those required for vacuum tube equipment. Thirdly, the higher efficiency of transistors means less heat and heat is one of the most destructive elements of electronic equipment.

The use of transistors resulted in many advantages heretofore impossible. Transistorized Raydist equipment became light enough

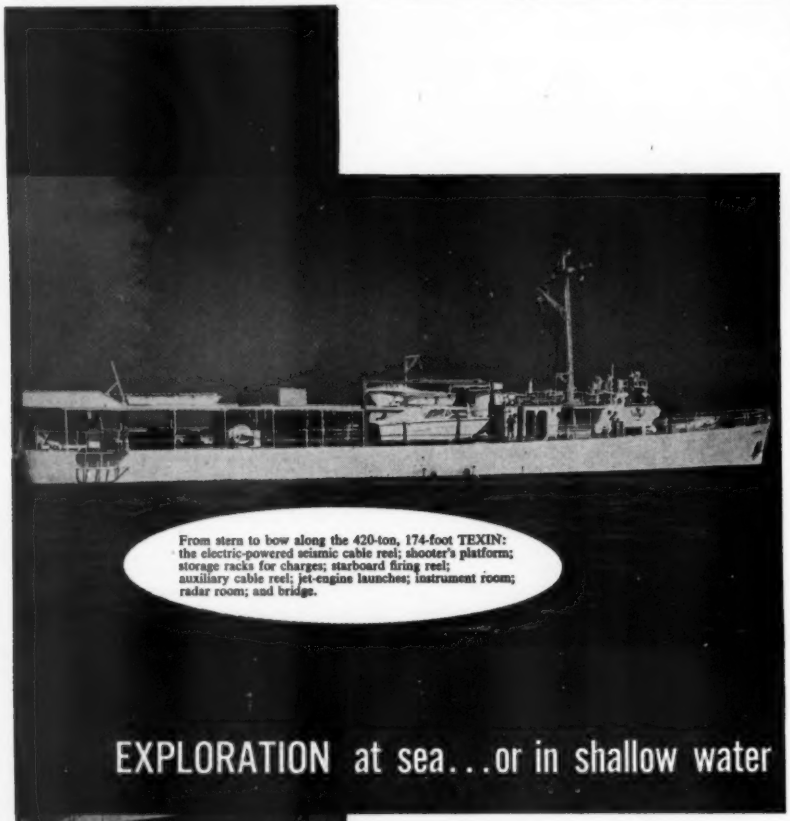
THE AUTHOR

Joseph T. Bradbury is a native of New York State, and received a B.S. degree from Union College in Schenectady.

Prior to joining Hastings-Raydist, Inc., he was employed by Westinghouse. In 1943 he volunteered for active duty and was commissioned an ensign in the U.S. Navy. He was released from duty as a lieutenant, and worked for the Office of Naval Research, Special Devices Center, while completing several graduate courses in electronics at New York University.

Bradbury later transferred to the Underwater Explosions Research Division of the Navy in Portsmouth, Va., where he was placed in charge of the electronic instrumentation section.

In October, 1951, he commenced work with Hastings-Raydist, Inc. as a liaison engineer. He has developed several patents related to both computing and electronic systems. He is a member of the Institute of Radio Engineers, American Institute of Electrical Engineers and the honorary electrical engineering society, Eta Kappa Nu.



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to be carried and installed by one person. It operated so efficiently that two 12-volt storage batteries could supply the stations for more than 12 hours and provide operating ranges of over 25 miles. Over two years of field operations with the equipment has shown it to be more reliable than its vacuum tube counterpart.

A typical Miniaturized Raydist base station, exclusive of batteries, weighs less than 50 lbs. The single telescoping antenna collapses to seven feet when in transit. A station of this type can be installed in less than one half hour by one person, and once it is turned on it is completely automatic.

Fig. 4 shows the shipboard position unit or "Navigator" as it is called. The two indicators give the two distance measurements from the vessel to the shore stations. On the right the automatic position recorder is shown. This unit make a continuous permanent record of the path of the vessel with an accuracy of a few feet even at the maximum ranges. This Navigator is so small it can be installed in the smallest boat, and like its companion shore stations, it is powered from two 12-volt storage batteries. The small size permits operation in shallow or swampy areas where heavier equipment would not be feasible.

Range . . . Although unquestionably the world's smallest precision electronic equipment for determination of distance and position, it operates accurately and reliably out to ranges of 25 miles. Where longer ranges are desired, the shore stations and shipboard transmitter can be augmented with the high-powered Raydist equipment. The same Navigator, when used with the high powered equipment, gives reliable operation to distances as great as 200 miles over sea water.

Easier maintenance . . . Another important feature of the Miniaturized DM Raydist system is the application of modular construction techniques in the Navigator and base stations. This improvement in the engineering design of the equipment facilitates its maintenance since the modules are of the plug-in type as shown in *Fig.* 6, and replacements can be accomplished in seconds. The Navigator and base stations, moreover, have a number of common plug-in modular components which reduce the number of spares required for maintenance.

Thus, the new transistorized Raydist DM System offers the user many advantages over former systems and equipment. The number of shore stations required has been reduced to two, resulting in a savings of time, equipment and personnel. The need for complicated charts or overlays has been eliminated. The small size and light weight of the equipment makes it economically practical to ship an entire system by air to any remote location. It also enables it to be used in small craft and in shallow or marshy areas where heavier equipment and larger vessels would not be feasible. The plug-in modular construction facilitates maintenance and eliminates down time.

In the three short years since the inception of the miniaturized Raydist DM System, it has been used extensively throughout the world. Because of its high accuracy and its small size, it offers an ideal solution to the problem of rapidly obtaining accurate position data at a minimum of cost. This new miniaturized Raydist DM System has resulted in substantial financial savings to its users and has also made possible many surveys which heretofore would have been physically impossible or financially impractical. No doubt, the forthcoming years will see even greater use of this equipment in all parts of the world.

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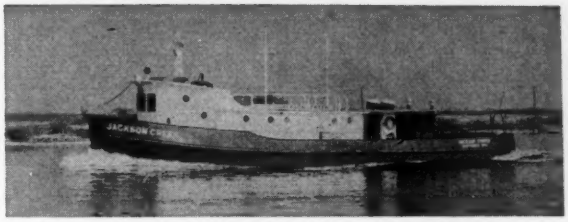

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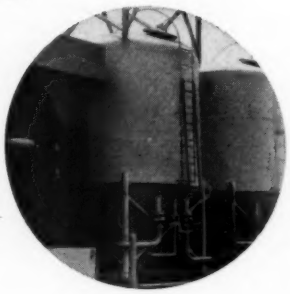

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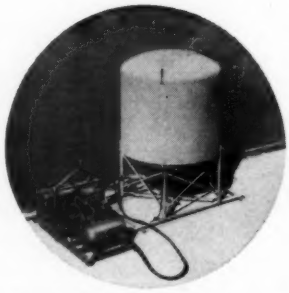

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FIGURE 1—MASTER TRANSMITTING ANTENNA. The motor vessel Calypso, operated by world-famous oceanographer and underwater explorer Commandant Jacques-Yves Cousteau, is here seen equipped for two-range Decca surveying in the western Mediterranean. Prominent is the 45-ft. base-insulated master transmitting antenna. The receiving antennas, in fibre-glass tubes, are visible to the right of the radar scanner.

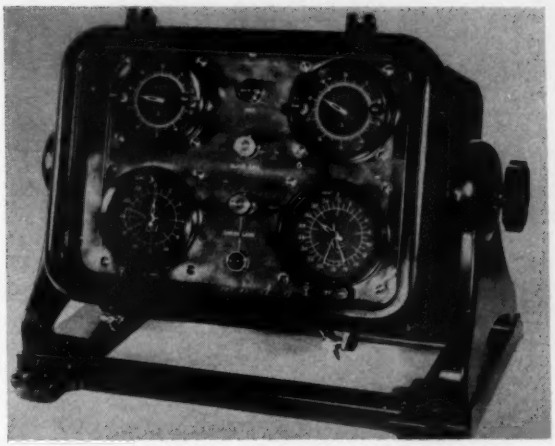

FIGURE 2—LAMBDA READOUT METERS (Decometers). The upper dials give the fine co-ordinate readings and the pointers make one revolution per lane. The lower meters indicate the whole-lane numbers. When the operator presses the central "check lane" button, the sector-shaped lane identification pointers will move round so as to enclose the lane-counting pointers if the latter are reading correctly.

Special Offshore Report

Decca "Lambda" Surveying System

By CLAUD POWELL

The Decca Navigator Company Limited

New Malden, Surrey, England

Everyone concerned with the surveying aspect of oil exploration is familiar with the essentials of various radio positioning devices that have aided operations offshore since World War II. It is common knowledge that such systems generally enable the user to fix his position, either in terms of a grid of lines representing constant differences in distance to pairs of stations on shore (in practice one station is generally common to the two pairs), or by reference to concentric-circle patterns centered on two shore stations.

Some systems can operate in either mode and Decca is one of these. That is to say, a Decca layout can comprise three shore stations producing two intersecting patterns of distance-difference lines (hyperbolae), or two shore stations each generating a pattern of direct-distance lines (concentric circles). The choice of which layout to use is a matter of operational convenience. The hyperbolic arrangement can serve any number of ships or aircraft or vehicles simultaneously, while the circular "two-range" version is limited to a single marine craft which carries with it the master transmitter as well as the receiver and display equipment. In compensation for its single-user restriction, "Two-Range-Decca" as it has become known, offers the simpler co-ordinate system and a rather higher overall accuracy.

Mobile system for hydrography . . . Two-Range Decca was developed from the Decca Navigator system which is widely used—now by about six thousand ships and many hundreds of aircraft—in Europe and Eastern Canada for general navigational purposes. The navigational transmitting stations are permanent installations operating on a 24-hour basis, however, whereas the two-range version was designed from the outset as a surveying system and uses mobile stations that are compact enough to be carried in a helicopter or a small boat.

Once the two "slave" stations are set up ashore, the equipment on the ship can measure the distances to them with an accuracy as high as 15 feet, and, in favorable conditions, can operate at a distance from the shore as great as 400 miles. In the tropics, atmospheric noise tends to limit the ranges to 150-200 miles; even so, hydrographic and oceanographic operations are benefiting very greatly from the ability to fix position accurately with respect to known points at ship-to-shore distances such as these. Two-Range Decca has for several years been a standard aid to surveying in the Hydrographic Department of the British Admiralty, five of whose survey ships each carries its own mobile chain of stations, and is also employed by the Canadian, New Zealand and South African hydrographic services. A new version of the system, known as "Lambda" (Low AMBiguity DeccA) is now in use by the Royal Australian Navy.

Lane-identification . . . A well-known feature of the radio position-fixing systems that operate on the phase-comparison principle, and one that applies to Decca in its basic forms, is "lane ambiguity". The position line patterns, whether hyperbolic or circular, take the form of a large number of recurring "lanes", and what the electronic equipment actually does is to indicate the ship's position within a lane; thus, if the phasemeter readout indicates 0.60 it means that the ship is six-tenths of the way across a lane, but the basic measurement contains no information as to which lane this is. An early American comment on Decca (for which the writer, as an occasional lecturer on phase-comparison systems, has been duly grateful) puts this in a nutshell: "The system tells you very accurately which pew you are sitting in, but not which church". The simple way to resolve the ambiguity is to have a geared pointer on the indicator which registers a change of one unit for each lane that the ship passes through; setting-up this lane-counting pointer at your start point to the correct number, as seen on the chart overprinted with the numbered lanes, will ensure that the correct whole lane can always be read off so long as reception is not interrupted. This is standard practice with Decca and many other systems.

At distances less than about 100 miles from shore, the ambiguity problem has seldom proved serious. Reception is very infrequently interrupted, and in any case there are several ways of detecting the occurrence of a lane error. Of considerable value here is the pictorial map display which is generally used with Decca surveying equipment, which records the ship's track as a pen trace on a chart; a jump of as much as a whole lane would amount to roughly 500 feet in the two-range system, introducing a conspicuous kink or step in the track record. In recent years, however, improvements in the equipment have enabled ranges of several hundred miles to be realized in practice, and at distances of this order it is obvious that the consequences of an error in lane-count could

become extremely costly and time-consuming. The permanent Decca Navigator chains of stations all have a "lane identification" facility whereby additional transmissions actuate a separate meter which gives the users, three times per minute, the required whole-number information. Until recently, lane identification could not be built into the mobile Decca transmitting stations since it demanded extra equipment which would have almost doubled their size.

The lane identification principle is based on the transmission of long-wave length signals from each station, and these signals combine to create patterns of hyperbolic or circular lanes that are very much wider than the normal ones. If a coarse lane embraces, say, 36 of the fine lanes, an additional meter responding to the coarse lane pattern will pick out the correct fine lane in a group or "zone" of 36. The necessary long-wave length (low frequency) signal from each station is provided in the form of a beat-note between the normal transmission and an aditional one radiated from the same antenna. In the conventional Decca lane identification system the two signals are radiated simultaneously, demanding a large measure of duplication in the transmitting equipment and a complicated double-tuned antenna coil. In the Lambda method the two signals are radiated in succession, so that the single set of transmitting equipment performs a dual function and there is no increase in the size of the station. In fact, the stations used in the Lambda system are considerably smaller than the earlier type which had no lane identification. A point of interest is that the receiver circuit which memorizes the phase of the first signal while the second is being transmitted (so giving the illusion that the two are transmitted together) uses a technique borrowed from "Dectra", a long-range air-navigation aid which covers the North Atlantic routes and is at present under flight evaluation by Pan American and other airlines.

In practice, the introduction of lane identification in the two-range system has proved a very worth-while innovation. Without it, the width of the lanes, which is constant in a concentric-circle system, is such that it was necessary to know your distance from the "red" shore station to better than plus/minus 700 feet and from the "green" to better than plus/minus about 450 feet, to be certain of setting in the correct whole-lane numbers; with the new system, it is necessary only to have prior knowledge of position to within plus/minus 3 miles in each of the two co-ordinates. In the unlikely event of a break in continuity of reception when at sea, therefore, a celestial observation, or possibly some other radio position-fix of relatively low precision, is sufficient to check and correct the lane-count.

Multi-user, amphibious system . . . If more than one ship or vehicle require the same position-fixing service simultaneously, the master transmitting station is sited ashore. Normally it is placed roughly midway between the two slave stations, with master/slave distances somewhere within the limits of 30-100 miles depending upon the requirement and operating conditions. Mobile Decca chains sited in this "hyperbolic" layout have been used for a very large number of survey, exploration and other projects during the last 13 years. These have included airborne magnetometry, gravity surveys using motor vehicles, marine seismic work, hydrography, and many special operations such as the laying of marine cables and the survey of underwater pipe-line routes.

A multi-user Lambda chain has been in operation throughout the 1960 season at a point within 10° of latitude of the North Pole. It provides navigational and position-fixing services for the Canadian Government's Polar Continental Shelf project, and receivers are carried in vehicles ranging from sledges to fixed-wing aircraft and helicopters. The extremely rugged conditions under which this particular equipment has had to operate (and will be operating in 1961) is a reminder of the need for electronic surveying equipment to be designed and built to rigorous engineering standards. The electronic units for the Lambda ground stations are all housed in watertight military-pattern transit cases; standby facilities are built in to permit station maintenance without wasting valuable time by going off the air; and all sub-assemblies and components in the transmitters and receivers—including such items as transistorized power supplies, and the electronically-controlled ovens housing the radio frequency crystals—have to be reliable in the humid heat of the tropical oil-exploration areas no less than in the arctic cold of the Polar Shelf.

THE AUTHOR

The author joined the Decca Navigator Company in 1946 on demobilization from the Royal Artillery as a Lieutenant-Colonel. Since that date he has been largely concerned with development of the Decca Navigator system as an aid to surveying, and originated the two-range method described in this article. He is also in charge of the Decca Company's Technical Information Department.

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Three recent developments . . .

The Gas Exploder, Sparker And Harru

By CHARLES B. OFFICER
Marine Geophysical Service Corp.
Houston, Texas

During the past three years, Marine Geophysical Services Corp. has introduced three new systems for geophysical exploration in water-covered areas. They are the Continuous Seismic Profiler (Gas Exploder), Continuous Seismic Profiler (Sparker), and Precision Radar Location System (Harru).

The Gas Exploder is a seismic reflection profiling system. An explosive mixture of propane and oxygen detonated in an open chamber beneath the water surface is the seismic source.

The Sparker is also a seismic reflection profiling system. It predates the Gas Exploder. Its sound source is the underwater detonation of a 12,000 volt spark.

Harru is a precision radar location system. Location is determined by two precision radar ranges. The two ranges control an automatic plotter which plots the survey boat's position continuously during the survey.

The Gas Exploder is used primarily for petroleum exploration purposes. The Sparker is used for petroleum exploration, minerals exploration, and marine engineering purposes.

Articles on the Sparker and Gas Exploder systems include **Deep Sea Research,** Vol. 4, pp. 36-44 (1956); **Petroleum Week,** March 13, 1959; **World Oil,** April, 1959; **Offshore,** July, 1959; **Geophysics,** Vol. 24, pp. 749-760 (1959); **Petroleum Week,** June, 1960; and **Western Oil & Refining,** August, 1960. The most recent development on the Gas Exploder and Marine Geophysical's adaptation of Harru are presented here for the first time.

The original development of the Sparker was made at Woods Hole Oceanographic Institution. The Gas Exploder source was developed at Lamont Geological Observatory. Humble Oil & Refining Company made the original development on Harru (Humble Accurate Radar Ranging Unit).

Gas Exploder . . . The general principles of operation for both the Gas Exploder and Sparker are shown schematically in **Fig. 1.** The seismic shots are repeated at frequent, regularly spaced time intervals with the survey boat underway. The shots are triggered at the zero time on the recorder. The reflected signals from each shot are recorded adjacent to each other on the record. For the Gas Exploder the shots are repeated every 2-4 seconds, and for the Sparker every 1/8-1/2 second.

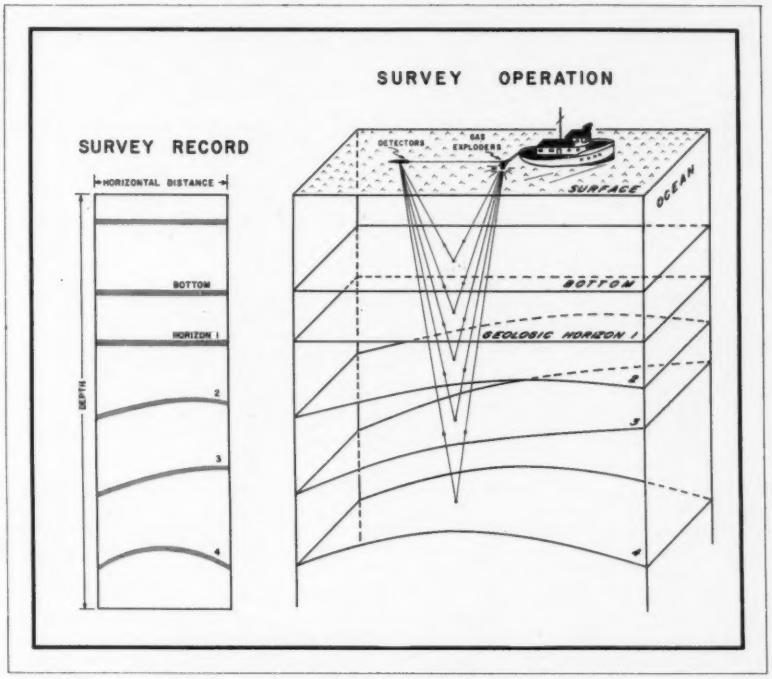


FIGURE 1—Schematic representation of Gas Exploder operation.

The record that is produced is in essence a geologic cross section. The horizontal scale is essentially hori-

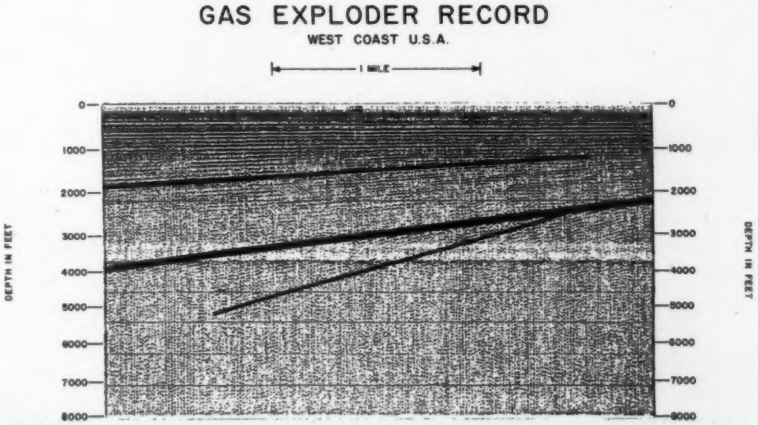


FIGURE 2—Gas Exploder record. Gently dipping strata underlain by more steeply dipping strata; heavy black line marks angular unconformity. For best casual appraisal of structural continuity view from the end of the record held approximately at eye level rather than face on.

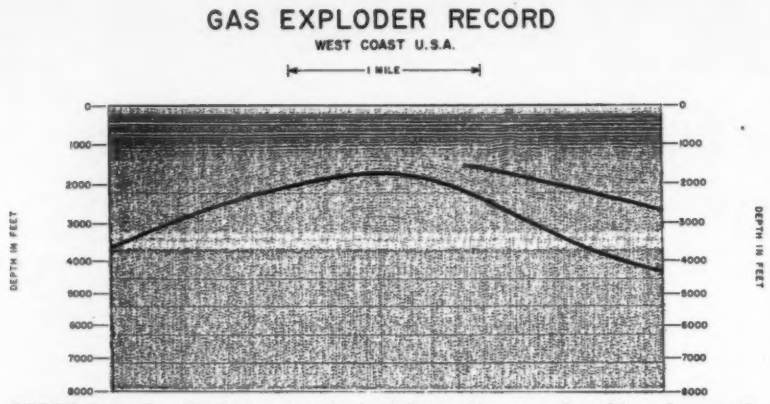


FIGURE 3—Gas Exploder record. Anticline with uncomfortable onlap on the right flank. For viewing refer to caption, Fig. 2.

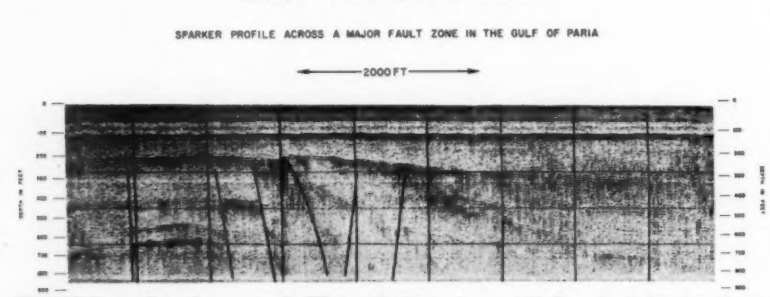


FIGURE 4—Sparker record. Water bottom is at 110-ft.; mud bottom is at approximately 220-ft. on the left and increases in depth to 330-ft. in the down dropped section to the right. Reflections from older geologic horizons are beneath the mud bottom; they have been severely faulted, six faults having been marked on the record.

zontal distances along the survey boat's track, and the vertical scale is vertical time (depth).

Surveys are made at a boat speed of 3-4 mph. There are no particular requirements for the survey boat beyond that it be seaworthy for the area of operation. Installation is made in one half to one day. The survey personnel consists of two people. Depending on the particular survey problem and expected results, the detectors will consist of a single hydrophone or an array of hydrophones.

Two types of gas gun systems have been used for the gas exploder. The most efficient recent development consists of two large guns fired simultaneously. The guns are towed immediately astern of the survey boat beneath the water surface. They are open cylinders at their lower end and with dimensions of 3-ft. in length by 4-in. inside diameter. They are fired at a repetition rate of once every 4 seconds. The records are taken with a bandpass filter setting of around 30-60 cycles per second. Continuous reflections are obtained to depths of 4,000-6,000-ft.

Figs. 2 and 3 are records taken with the large guns. **Fig.** 2 shows moderately dipping strata interrupted by an angular unconformity. **Fig.** 3 shows an anticline.

The earlier gas gun system consists of three small guns fired simultaneously. They are also open cylinders but with dimensions of 1½-ft. in length and 2-in. inside diameter. They are fired at a repetition rate of once every two seconds. The recordings are taken with a bandpass filter setting of around 50-90 cycles per second. Continuous reflections are obtained to depths of 2,000-3,000-ft. The small guns give less depth of penetration but show somewhat more structural detail. Because of the lower oxygen and propane consumption, the small guns are sometimes preferable for survey work in relatively inaccessible areas.

Sparker . . . The primary difference between the Sparker and the Gas Exploder is the sound source. The Sparker source is the underwater detonation of a high voltage spark discharge. The sound spectrum of the spark is similar to that of a small blasting cap. The spark spectrum can be varied, lower for petroleum and mineral exploration purposes and higher for detailed engineering purposes.

The recordings are taken with a bandpass filter setting of around 300-600 cycles per second or higher. Continuous reflections are obtained to depths of 600-800-ft. beneath the bottom. The Sparker shows considerably more detail of the underlying structure and stratigraphy than the Gas Exploder. It is possible to operate both a Gas Exploder and a separate Sparker system on a given survey, thus obtaining both the deeper

THE AUTHOR

Charles B. Officer received his Ph. D. in geophysics in 1951 from Lamont Geological Observatory, Columbia University, in 1951. From 1951 until 1955 he was the geophysicist on the staff of the Woods Hole Oceanographic Institution. During that time he spent a year in New Zealand as a Fulbright Research Fellow. From 1955 to 1957 he was an associate professor of geology at Rice University. In 1958 he formed Marine Geophysical Services Corp. with which he is presently associated as president. In 1959 he formed Marine Geophysical Services International Inc. of which he is presently president. In 1961 he joined Alpine Geophysical Associates, Inc., and is executive vice president of that company.

Dr. Officer has written a number of technical papers on geophysics, geology and underwater sound, including a book entitled "Introduction to the Theory of Sound Transmission." He received the Best Paper Award from the Society of Exploration Geophysicists in 1953, and was a Distinguished Lecturer for that society in 1954.

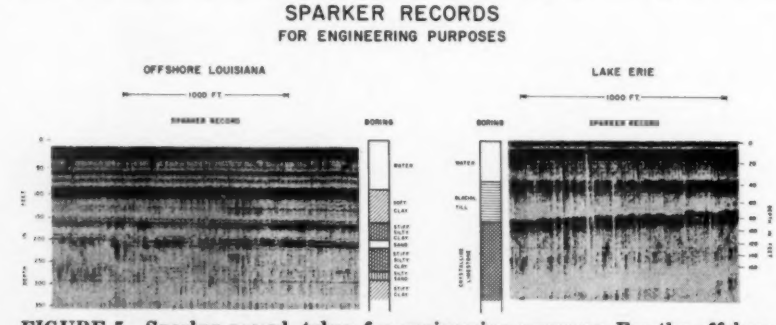


FIGURE 5—Sparker record, taken for engineering purposes. For the offshore Louisiana portion the water bottom, top of the stiff silty clay, and the sand lens are shown clearly; the stiff silty sand lens is shown weakly. All correspond in a one-to-one manner with the boring. For the Lake Erie portion the water bottom and top of the crystalline limestone are both well defined.

Gas Exploder information and the more detailed Sparker information.

Figs. 4 and **5** are Sparker records. **Fig. 4** is an example of a petroleum exploration record. It shows a complex fault system overlain unconformably by a variable thickness of recent deposits. **Fig. 5** is an example of two engineering records and comparison borings. The first record is from Lake Erie and shows an overburden of glacial till beneath the lake bottom down to the limestone basement. The second record is from the Gulf Coast and shows a soft clay layer beneath the water bottom underlain by a stiff clay with a sand lens and a deeper silty sand lens.

Harru . . . Harru is a precision electronic location system for offshore surveying. Location is given by two accurate radar ranges, monitored continuously, from two known targets. The system includes an automatic plotter which plots the survey boat's location and track directly during the survey.

The system operation is shown schematically in **Fig 6**. The monitoring is done directly on the radar scope with a delayed sweep. The scope is divided into two sections with separate crystal controlled delay times to cover the range intervals for the two targets used. The system operator turns the two wheels shown in **Fig. 6** to keep the reference arcs on the two targets. The ranges are then read at fixed time intervals on counters attached to the ranging unit.

The two ranges are also fed into the automatic plotter. The two plotter boxes are fixed at the target locations on the survey map. The apex of the two plotter arms is the location of the survey boat. The apex includes a scriber which marks the map at the same fixed time intervals for which the operator records the radar ranges. The intervalometer which controls the scriber also puts a mark on the geophysical records for each location point on the map, thus providing a one-to-one relation between the survey records and the location control.

The two radar ranges may be taken from radar transponder beacons located onshore, topographic prominences, or offshore buoys, drilling platforms, etc. When radar beacons are used, the radar pulses received are transmitted back to the survey boat by the beacons at a slightly lower frequency and in the form of a recognizable, coded signal. The use of the radar beacons generally provides the most accurate and longest range use of Harru, for the radar beacons can be located at known points onshore, and they transmit a sharp, strong signal. The radar beacons are self-operating and do not require any shore attention other than their initial emplacement. The use of topographic prominences or offshore buoys, etc., provides an advantage to the system for remote, inaccessible areas in that no shore contact or personnel are necessary.

Harru provides a versatile offshore location system with complete control on the survey boat. Installation is straightforward, no licensing problems are involved, and the system is operated by a limited number of personnel.

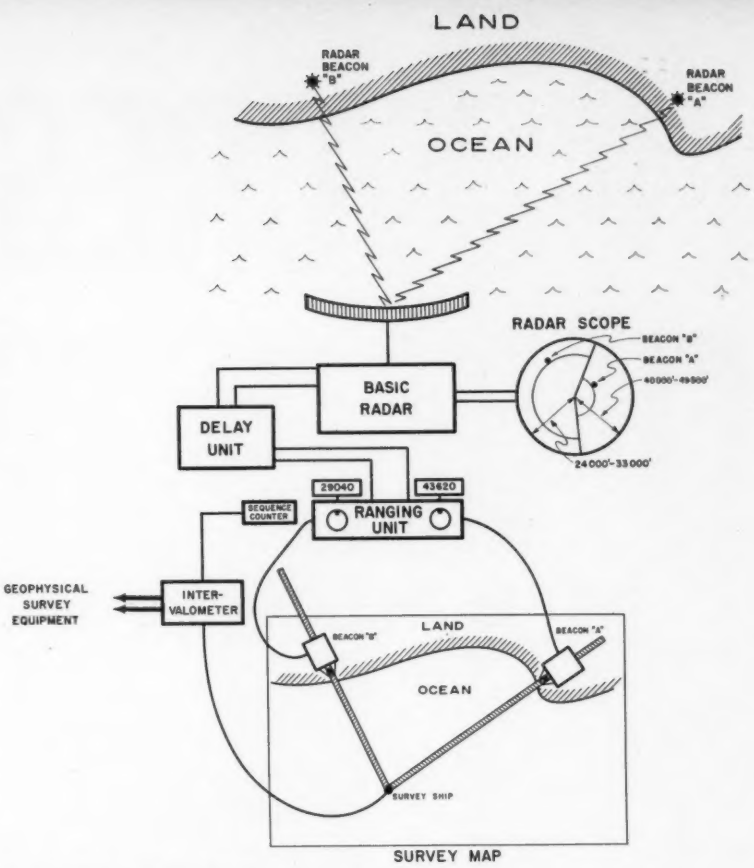
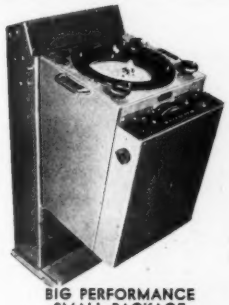


FIGURE 6 — Schematic representation of Harru operation, equipment, and automatic plotter.



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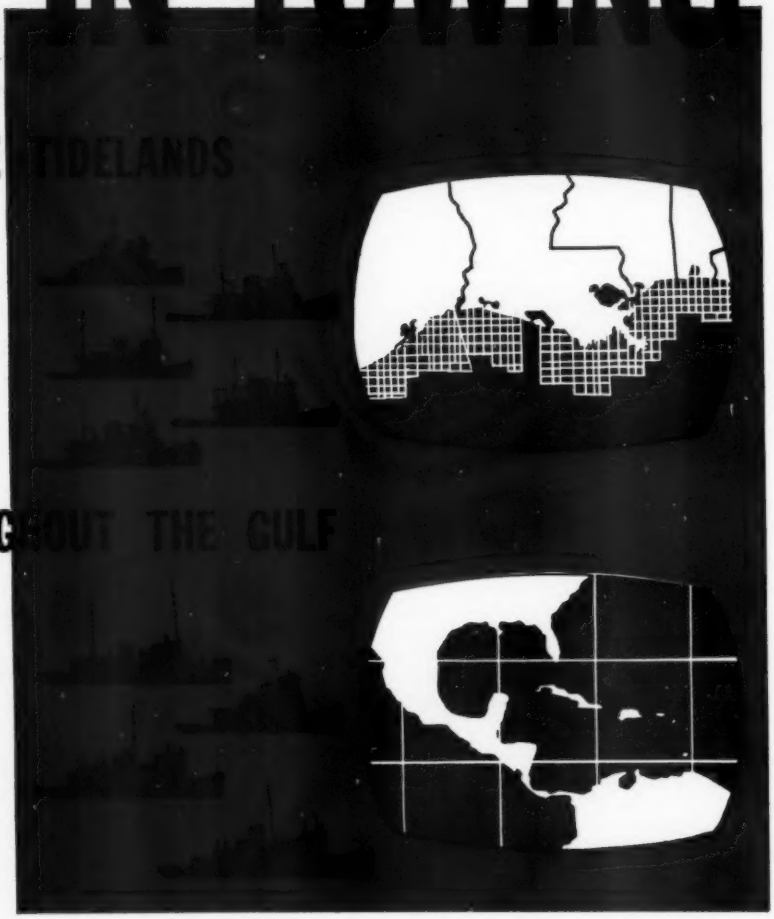

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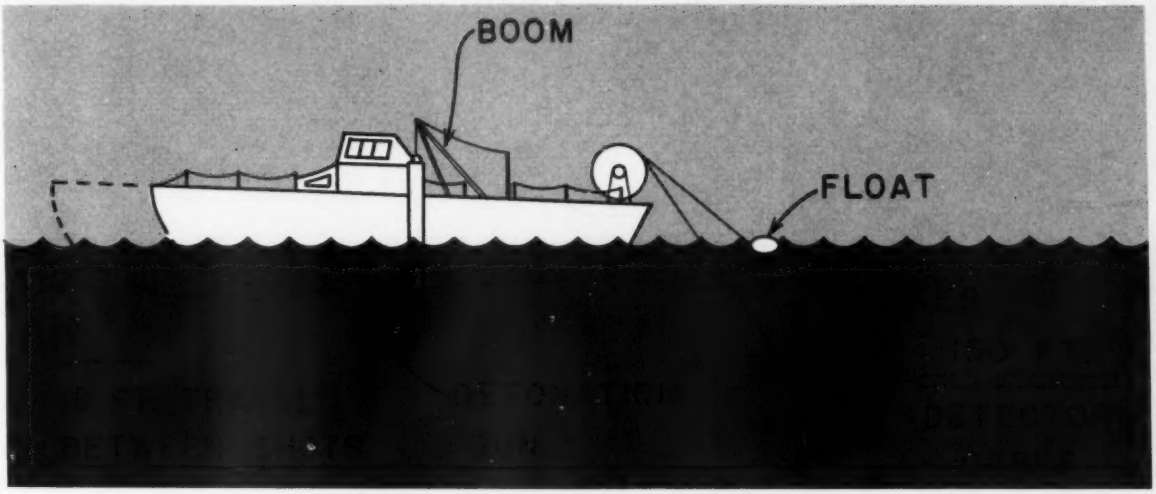

FIGURE 1—Low frequency echo sounder system. Boat speed 4 mph. Interval between shots 3.0 sec.

Special Offshore Report

New Marine Seismic System

By F. J. McDONAL
Socony Mobil Oil Company, Inc.
Dallas, Texas

The marine seismic system described here was developed by Socony Mobil to provide a low cost seismic system for use over water-covered areas. The method is a one-boat operation which employs a detonation gun as the source of seismic energy for obtaining variable-density records in a repetitive manner as the boat moves forward at a uniform speed. In the Gulf of Mexico and in the bays along the coast, records consistently show good reflections from depths of four to five thousand feet, and in other areas from eight to ten thousand feet.

The system is illustrated in *Fig.* 1. A detonation gun is supported over the side of the boat with the open end of the gun submerged approximately three feet beneath the surface. The gun itself is a steel tube approximately twenty feet long and six inches in diameter which utilizes a fuel mixture of propane and air, or propane, air and oxygen. A spark ignites the fuel and the burning gas develops a shock wave which strikes the water at the submerged end of the gun. The gun is fired at intervals of 3.0 sec. At a boat speed of approximately four miles per hour, the distance between shots is 18 feet. A detector cable is towed behind the boat at a depth of 4 to 25 feet depending upon water depth. An arrangement of a float and sinker provides adjustment of the detector depth, and insures that the cable will tow at a constant depth.

A simplified diagram of the system is shown in *Fig.* 2. Signals picked up by detectors connected in parallel are amplified by a conventional seismic amplifier with a conventional choice of filter settings. AVC is used, at present, for gain control. The output of the amplifier is fed to the magnetic drum compositor which adds signals from 2, 3, 4 . . . 16 shots to form one trace of the final record. The compositor output in turn is fed to an electrosensitive-type chart recorder which provides a variable-density section that can be viewed while the recording is in progress. No chemical development nor processing is required. The chart recorder also generates a pulse at three-second intervals which is converted by a standard pulse circuit to a high-potential spark to ignite the fuel in the detonation gun. The section is then a series of three-second, variable-density seismic traces recorded across the 18-inch width of the chart paper with the traces spaced 1/64 of an inch apart to give the appearance of a continuous variable-density section.

Detonation gun . . . The detonation gun is the key element of this system. The gun itself consists of a mixing chamber, a spark plug, and a tube approximately twenty feet long and two to eight inches in diameter. Auxiliary equipment includes propane and liquid oxygen storage tanks, an air compressor, and the necessary valves and flow meters to provide a constant flow of the desired fuel mixture. At the moment of the spark, a burning front is created which advances from the region of the spark plug downward through the gun. As the combustion proceeds additional energy is added to the moving flame front, and the velocity of the flame front increases and eventually exceeds the velocity of sound. The result is a shock wave which strikes the water at the submerged end of the gun. The mixture of propane and air is not critical, but the addition of oxygen does provide a wider range of satisfactory mixtures. Also, the

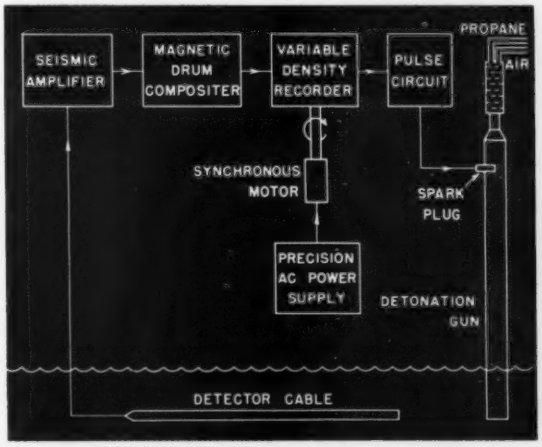

FIGURE 2—Block diagram of low frequency echo sounder system.

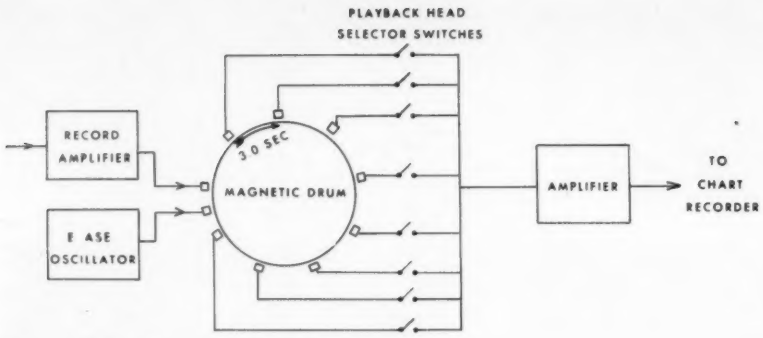

FIGURE 3—Magnetic drum compositor.

energy of the detonation is greater when oxygen is added.

Detector cable . . . The detector spread employed in this system may be considered as one trace of a conventional seismic system. However, in this application, noise from the boat and noise due to turbulence created by the cable being towed through the water must be minimized since recording is continuous. This has been achieved by 1) employing a detector cable with 20 elements to serve as a pattern for noise rejection, and 2) by the use of a streamlined plastic tube to house all of the detectors and associated cables. This cable is a modification of a standard marine cable furnished by Marine Seismic Surveys, 6111 Maple Avenue, Dallas, Texas. The active part of the cable is 150 feet long and contains 20 ADP crystals spaced seven and one-half feet apart. A 150 foot dummy section provides some isolation from the turbulence created by the sinker and float.

Seismic amplifier . . . The amplifier needs no special description. It is conventional with the possible exception that particular interest was placed upon low noise in the first stage (1/10 microvolt or less at 250 ohms). Filters also are conventional and a slow AVC is employed.

Magnetic drum compositor . . . The operation of the system as described in Figure 1 indicates that the boat travels a distance of approximately 18 feet per shot. Thus, signals from five to ten shots can be composited without exceeding the ground coverage normally employed in conventional seismic operations. Since the received signal is weak, and since we desire the maximum penetration for the system, it is clearly obvious that some degree of mixing and compositing is desirable. The system in its present form includes a magnetic drum compositor (Figure 3) which permits addition of signals from 2 to 16 successive shots. The drum is equipped with record and erase heads and 8 equally-spaced playback heads. At a recording speed of 1.7 in/sec the time between each of the playback heads is precisely 3.0 seconds. Since shots are also fired at 3.0 second intervals, seismic signals recorded for successive shots will be played back simultaneously at the respective playback heads grouped around the magnetic drum.

Consider a single shot and a record of 3.0 seconds duration. This record will be reproduced by the first playback head, then three seconds later the same signal will be repeated again at the second head, six seconds later at the third head, and so on around the drum such that 24 seconds later the same record is repeated for the eighth time at the eighth playback head. The playback head selector switches shown in *Fig.* 3 permit the operator to select the number of shots that are being composited at any one given time. Not shown in the drawing is another track on the magnetic drum which permits the sum of 8 shots to be stored and later added to another sum of 8 to give the composite of 16 shots.

Application . . . *Figures* 4 and 5 are typical of the records obtained in the Gulf of Mexico. The time scale shown on the margin of the figure indicates a three-

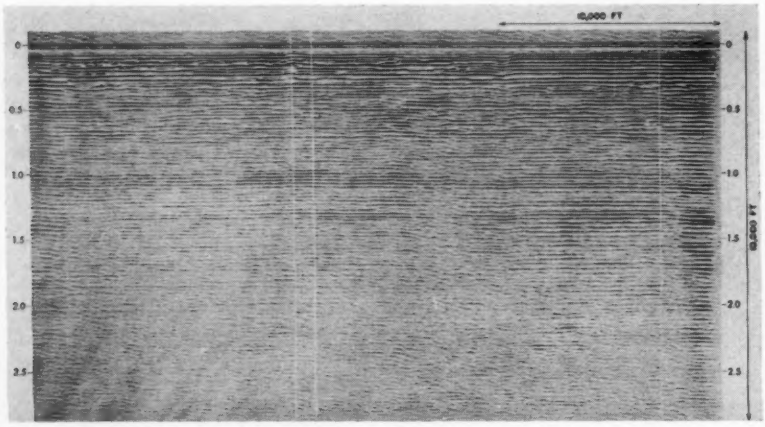

FIGURE 4—Seismic section offshore Texas.

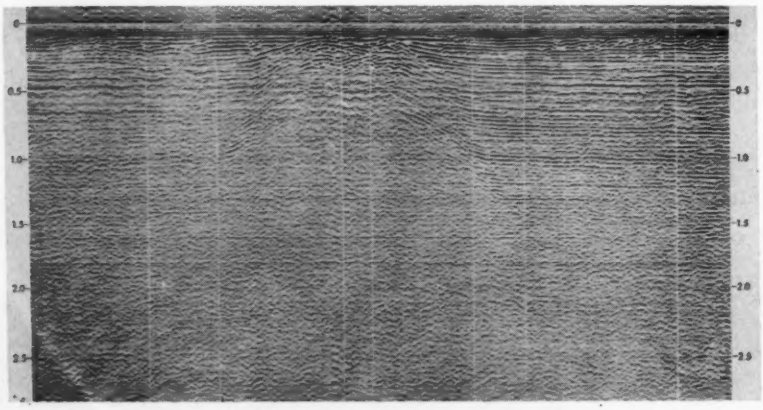

FIGURE 5—Seismic section offshore Louisiana.

THE AUTHOR

F. J. McDonal received a B.A. degree in physics from Hendrix College in 1940, and continued his work in physics at the Graduate School of the University of Missouri. In 1942 he was made an instructor in physics at the University of Missouri, and in 1944 joined the Field Research Laboratory of Socony Mobil Oil Company in Dallas, where he is presently employed. His work with Socony has included X-ray and electron diffraction studies of catalyst, development of a mass spectrometer method of microanalysis of hydrocarbons for geochemical work, development of analog Fourier analysis equipment, the study of frequency characteristics of seismograms, and the study of attenuation of seismic signals. At present, he is supervisor of the Geophysics Section of the Field Research Laboratory. He is a member of SEG, Seismological Society of America, Sigma Xi and other technical societies.

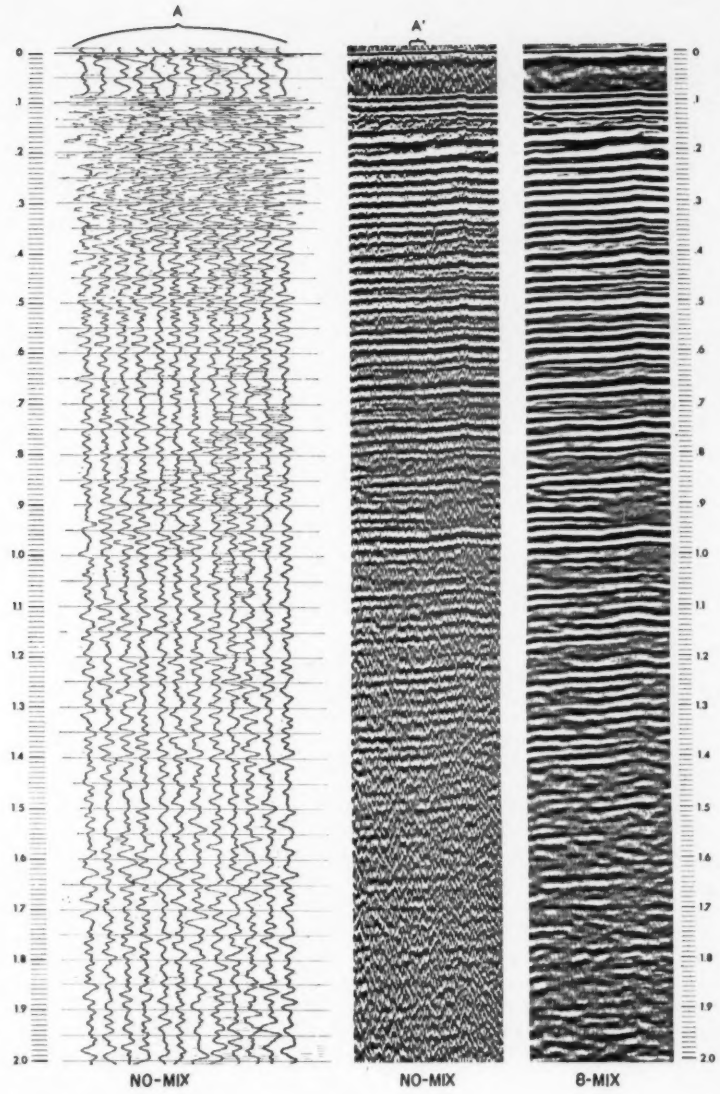

FIGURE 6—Record section comparison.

second interval across the entire width of the record section. At an average velocity of approximately 7,000 ft/sec, the width of the paper represents a total depth of approximately 10,000 feet. Thus the reflections appearing at the middle of the section represent depths of approximately 5,000 feet. The paper speed is 0.35 in/min, which is equivalent to a horizontal scale of 1000 ft/in at a boat speed of approximately 4 miles per hour. Thus, the section of Figure 4 represents a line approximately 6 miles long with a total depth of 10,000 feet near the bottom of the section. The horizontal line at zero time is a time-break from the pulse generator. The amplifiers and chart recorder are operating continuously, and as a result the top one-half inch above the timebreak is primarily noise at the end of the record. In general, we disregard this portion of the record.

The system also provides for conventional wiggle trace records and variable-area record sections. *Fig.* 6 shows such a comparison for records from Aransas Bay near Rockport, Texas. The conventional records at the left of *Fig.* 6, designated as A, are identical with the traces labeled A' of the variable area section. The No-Mix traces of *Fig.* 6 were recorded with no mixing or compositing, and with conventionl filters (25-70 cps) and AVC.

Conclusions . . . The authors believe that the system in its present form will be valuable as a reconnaissance tool at a cost of only 20 to 30 percent of that of conventional seismic prospecting. It is our expectation that we will be able to increase the power of the detonation gun, and improve the performance of the rest of the system. Such improvement should result in improved records with reflections from appreciably greater depths.

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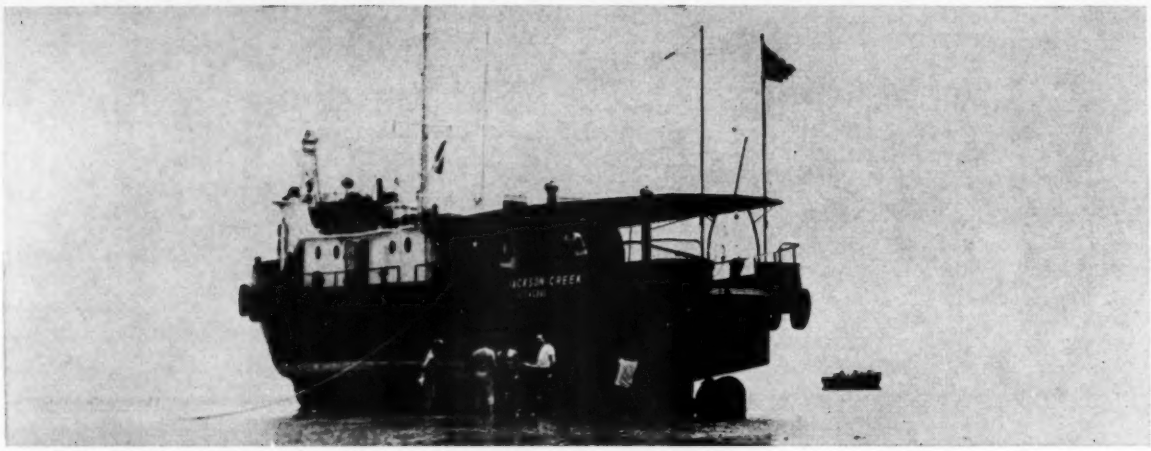
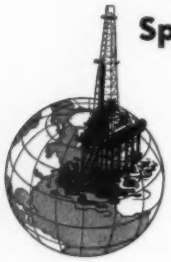


SEISMIC CREW TAKES A BREAK in operations while waiting for the incoming tide to refloat their vessels.



Special Offshore Report

Versatility Characterizes Two-Boat Seismic Operations

By CARL H. SAVIT and CHARLES F. SEBASTIAN
Western Geophysical Company of America
Los Angeles, California

Although a small amount of marine geophysical exploration was done over continental shelf areas in the 1940's, real interest in offshore seismic exploration did not develop until the early 1950's and the exploration industry went through a rapid transformation in the rush to become waterborne. Offshore seismic activity reached its zenith in 1954 when 38 crews were operated in the Gulf of Mexico alone. Although the total number of crews operating today is considerably less than the total for 1954, today's offshore crews have expanded their field of operations to include most of the continental shelf areas of the world. A measure of success for the offshore oil exploration techniques can be taken from the estimate that 40% of the world's known petroleum reserves are located under the offshore continental shelves.

UNDERWATER EXPLOSION spirals water high behind shooting boat.

For a picture of marine seismic exploration, let us look in on a present day two-boat seismic survey party at work. The technique which this party is using typifies four-fifths of the seismic reflection surveys made over the world.

The sun has just risen over a misty, calm sea as an offshore seismic recording boat begins its straight-line travels over a precise grid, guided by the unseen hand of an electronic navigation system. Suddenly the navigator, watching his constant position indicators and referring to predetermined coordinate positions, calls out "back her down" and the ship shudders a bit as the skipper moves controls to reverse the direction of the twin screws. The chief observer radios to the shooting boat, which is about 2000 feet away, to "make your run" and as the shooting boat passes by a buoy marking the center of the 2500-foot cable which trails the recording boat, the shooter pushes a capped explosive charge off the stern. Suddenly the throbbing on both boats ceases and the ocean is quiet as engines are idled and the propellers are disengaged. The shooter announces to the observer by radio that he is beyond 100 feet from the floating charge and arming circuits for the radio firing control system are set on both boats. A brief glance at the recording camera tells the observer that all detector stations along the cable are quiet and he pushes the button to start the recording and automatically fire the shot. The

great white column of spray rises several hundred feet into the air and as the spray still falls, you feel the ship come to life again as the propellers start the ship moving down the line again. A look at your watch indicates that only two minutes plus a few seconds have elapsed since the previous shot.

This, then is a brief description of the present two-boat reflection shooting technique for offshore seismic exploration as seen by the visitor. It does not tell the whole story, however, for it has taken hard work and careful planning to achieve the high degree of coordination which has impressed our visitor and enables marine seismic crews to shoot the continental shelf areas at per-mile costs considerably below the costs for typical land-based crews.

Modern seismograph exploration techniques have evolved to a point where it is necessary to perform a number of different tasks in a coordinated fashion on most prospects. No longer is it sufficient to survey an offshore prospect routinely, making only simple seismic reflection determinations at successive points. Problems such as changing rock velocities and seismic waves which are reflected several times from a given surface require the careful execution of specialized determinations. With the almost universally used two-boat technique, it is possible to pre-plan surveys so as to include special arrangements for velocity determinations as well as arrangements for the refraction technique in which the shooting boat and recording boat may be separated by many miles.

While present-day explosives and detonating equipment are extra-ordinarily reliable, it nevertheless occasionally happens that there is a misfire of a seismic shot. Many times these misfires can be attributed to the elaborate safety precautions which are maintained for the protection of the operating personnel. In any event, when such a misfire occurs, it is customary in the two-boat operation for the shooting boat to make a second pass over the shot point while the recording boat and cables are allowed to drift. The shooting boat can return to its previous location in less than two minutes and a shot can be taken with the cables still in their proper position. It is thus possible to avoid leaving troublesome gaps in survey cross sections.

Precise distance determinations necessary in refraction work and in the velocity techniques as well as in normal reflection shooting can be made by using sound waves that travel solely in water, as in the military Sonar techniques. Special amplifiers and recording equipment supplement the normal seismic equipment for these distance-measuring purposes.

Successful operation of the two-boat survey system requires near-perfect radio communications, not only for voice instructions between the observer and the shooter, but for radio firing of the shot from the recording boat and transmission of the shot moment back to the recording boat. It is now the practice to use frequency modulated transmission systems between the recording and shooting boats for virtual static-free reception. This is a particularly important advantage in transmitting the signal indicating the exact time of firing of the shot.

An additional bonus is now often being realized from many of the specially-constructed shooting and recording boats. Designed with flat bottoms and with adequate protection for the rudder and screws, and drawing less than seven feet of water, these vessels are able to traverse many tidal flat areas and tidal rivers. Preliminary surveys of essentially land prospects within the coastal areas of West Africa have been made at a fraction of the per-mile land survey cost by sending marine survey vessels up the many tidal rivers. The vessels cruise up the rivers until low tide halts their progress and they go aground, the flat bottom of the vessels safely resting on the river bottom. The vessels soon float free with the incoming tide and continue shooting up-river at high tide.

In recent years, offshore seismic exploration has been extended to the four corners of the globe and a variety of new operating conditions have been encountered. Whether the problems involved shooting up rivers, exploring in the shallow waters of tidal flats and around islands, combating extreme tidal currents and ice conditions, or the combination of several seismic survey techniques, the versatile two-boat seismic survey system has proved capable of any job.

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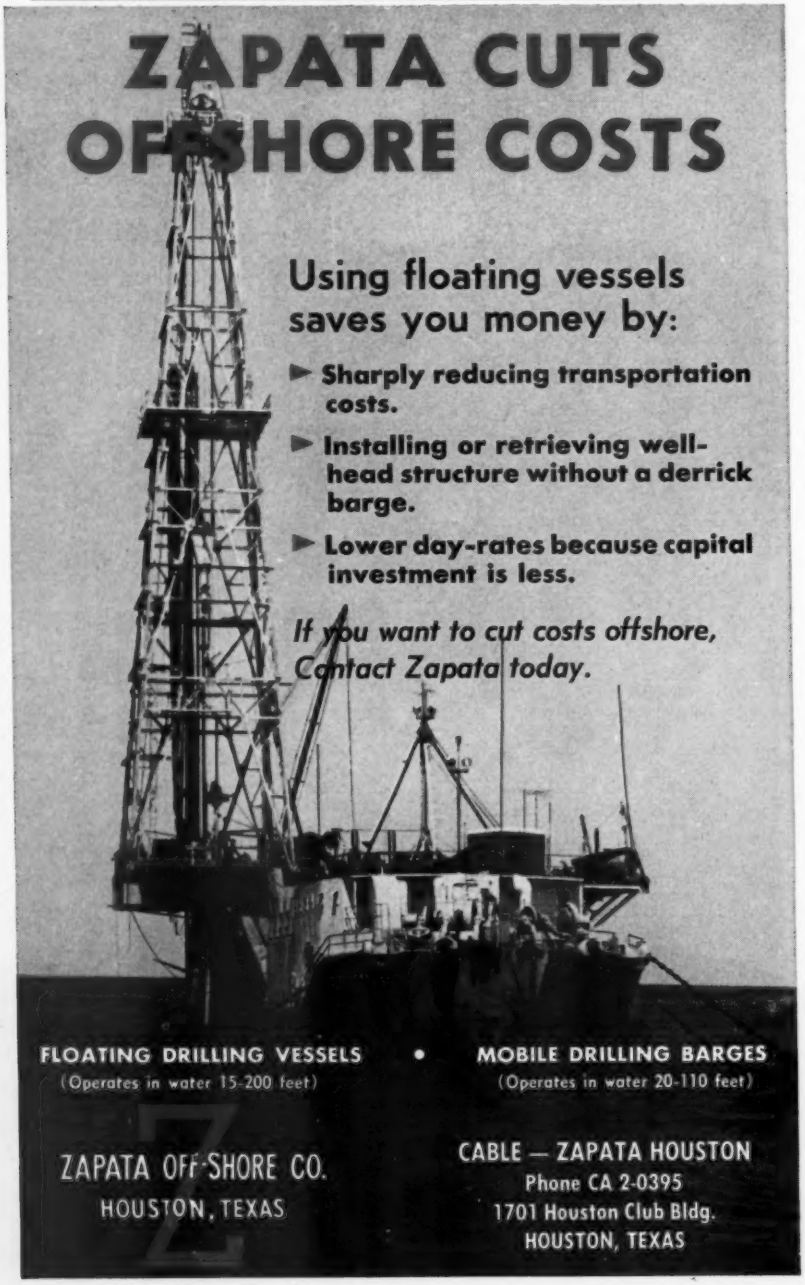
California

Third Offshore Parcel Up For Bidding April 7

Under the new "sequential bidding" inaugurated early this year, the California State Lands Commission has given notice that a third offshore tract (Parcel 2) is up for auction April 7.

The state hopes to derive more revenue from its offshore lands by offering tidelands tracts for lease one at a time. Four 4,250.14-acre tracts off Santa Barbara County are the first to be offered under the plan. Parcel 1 was put on the auction block Feb. 3, and Parcel 2 was offered March 3.

An outline of the conditions for bidding and the form of oil and gas lease, including the form of bid, may be obtained at the office of the State Lands Commission, Room 302 State Building, 217 West First Street, Los Angeles 12, Calf.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First Parcel Offered By State Fails To Draw Bid

The first offshore tract offered by the California State Lands Commission under its new "sequential bidding" went begging Feb. 3.

Parcel 1—a 4,250.14-acre tract off Santa Barbara County—was the first test of the state hope to derive more revenue by offering offshore tracts singly. It did not attract a bid, but this does not mean that oil operators have turned their back on California's offshore potential.

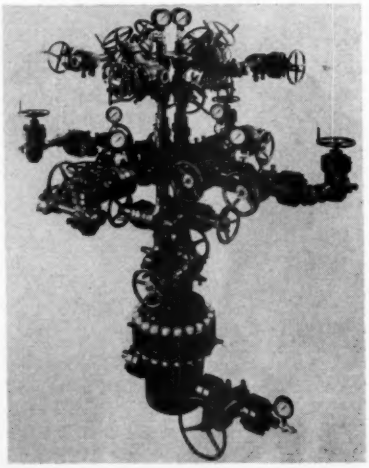
A variety of reasons were offered to explain the lack of interest in this parcel on the part of offshore operators, including the fact that it is near the Pacific Missile Range and is crossed by shipping lanes. It was not included in the acreage nominated by Shell Oil Company.

Japan

Submarine Pipeline Laid To Field Off Akita Coast

Japan Petroleum Exploration Company has laid a 1.4-mile submarine pipeline to its three wells in the Tsuchizaki field offshore from Akita prefecture in northwest Honshu.

The three wells were drilled from a platform erected in the Sea of Ja-



THE OIL INDUSTRY'S FIRST 8-string wellhead assembly was completed and shipped recently for use on a multiple-completion well in South Texas. The unit was designed around standard Oil Center Tool Company components, with the tree assembly supporting four strings of 2½-in. tubing each containing a string of 1½-in. tubing. The wellhead permits running centralizers or other tools through the hangers.

pan. The last well was completed at 2,000-ft. with a flow rate of 1,800 bpd, it was announced. Three wells completed about one-third mile away are expected to be put into commercial production next spring, when improved weather conditions allow pipelaying operations to resume.

Kuwait

Details Concerning Shell's Offshore Concession Given

The decision by the Emir of Kuwait to grant offshore oil exploration and production rights over an area of approximately 1,500 square miles to Shell was announced on November 30, 1960.

The full text of the agreement was signed in Kuwait on January 15, by the Emir of Kuwait and J. F. Stephens, managing director of the Royal Dutch/Shell Group.

A new company, The Kuwait Shell Petroleum Development Company Limited, has been established to handle all matters connected with the undertaking. The agreement is for a period of 45 years.

Shell will pay rental for the area of one million pounds for each of the first two years, two million pounds a year thereafter until regular exports begin. A bonus payment of seven million pounds was paid on signature and a further bonus of seven million pounds will be paid at the end of the fourth year or when production reaches 100,000 bpd, whichever is sooner.

Bonuses totalling a further 16 million pounds will be paid in four equal installments when production rates reach 200,000, 300,000, 400,000 and 500,000 bpd respectively.

It is hoped that a seismic survey will be completed during the first half of this year. Full interpretation of the informaton obtained will take a further six or seven months. It is expected that the first drilling location will be chosen by the end of this year and the first well spudded in early 1962.

The Emir of Kuwait will have an option on discovery of commercial production to join as a partner in the venture to the extent of 20 percent at cost. If the Emir decides to exercise this option, he may elect to do so through a Kuwait company, the shareholders of which shall all be Kuwait nationals.

Shell Plans First Kuwait Offshore Test Next Year

Royal Dutch/Shell, with its rights to a 1,500 square mile concession in the Persian Gulf off Kuwait secure, will begin evaluation of the area immediately.

A seismic survey is expected to be completed by mid-year. Study and interpretation will take several more months, so that actual drilling operations are not expected to begin before early next year.

Lake Maracaibo

New National Oil Company Announces Drilling Program

Venezuela's new national oil company, Venezuelan Petroleum Corp. (CVP), will soon start drilling operations in Lake Maracaibo on its 332,940-acre mid-lake concession.

Offset wells will be drilled to existing production on nearby blocks, and the company seems assured of having production of its own before the end of the year.

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Louisiana

Tennessee Gas Buys Huge Bastian Bay Gas Reserves

Tennessee Gas Transmission Company has added more than one trillion cubic feet of natural gas reserves to the total supply dedicated to its pipeline system by purchase from Pan American Petroleum Corporation of its producing leaseholds in Bastian Bay, Plaquemines Parish, Louisiana.

Consideration for Pan Amercan's net interest in the properties was in excess of $150 million, including a cash down payment and non-interest bearing notes payable over 18 years. Tennessee Gas will operate and develop the field.

The purchase was in line with the company's active program of acquiring new gas reserves to keep pace with the expanding requirements of its gas transmission. The large addition to the company's owned reserves affords valuable flexibility in dispatching and operations.

In winter, when customers' needs reach a peak, deliveries from the field can be increased, says the company. In summer, when demand for gas is lower, the field's gas output can be reduced.

Gas deliveries from the Bastian Bay leases into the Tennessee Gas pipeline system which crosses the area have commenced through newly-completed field connections.

Under terms of the sale agreement, Pan American, producing subsidiary of Standard Oil Company (Indiana), has transferred all of its leasehold rights, down to the base of presently known producing formations, and all well and lease equipment, to Tennessee Gas.

The sale involved 10 leases with 11 gas wells and 13 oil wells in which Pan American held 100 percent working interest, and three joint interest leases with one oil and two gas wells. Prior to the sale, Pan American was the major working interest owner and the operator of the field. Other working interest owners are not parties to the sale.

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Mineral Board Announces Change Of Lease Plans

The Louisiana State Mineral Board has scheduled a lease sale for Thursday, April 20, to be held in the Court of Appeal, Fourth Floor, State Capitol, Baton Rouge at 10:00 a.m.

No lease sale is scheduled for May 18, as was originally announced.

Applications will be accepted on inland and Zone I acreage, as defined in the Oct. 12, 1956 interim agreement between the State of Louisiana and the federal government.

Tracts advertised for the April 20 lease sale will be advertised in the Baton Rouge "State Times," the official state journal, and the respective parish journals wherein the tracts are located. Dates for the advertisements will be March 31, April 7 and April 14.

Trinidad

Three-Company Group Gets 2 Million Offshore Acres

A three-company group made up of Pan American International Oil Company, Pure Oil Company and Sun Oil Company has been awarded a huge offshore concession on the Atlantic side of the island of Trinidad.

The companies will each have a one-third interest in the 3,120 square miles block, which is 60 percent larger in area than the island of Trinidad itself.

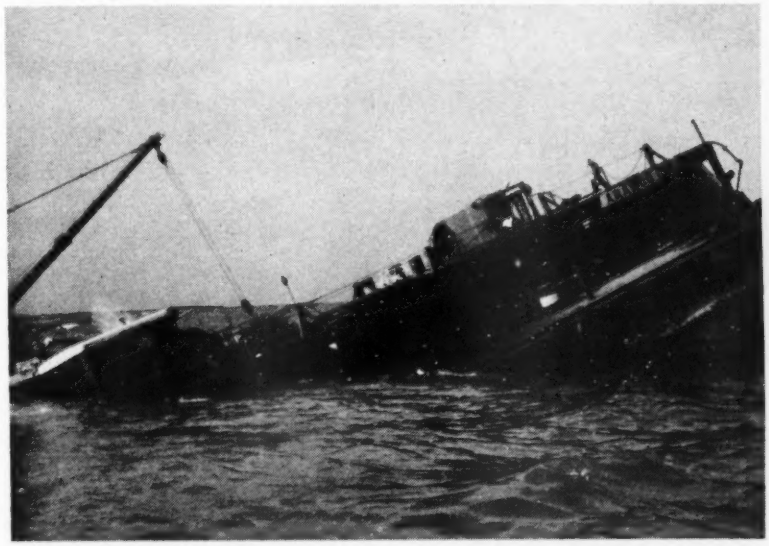
Pan American will be operator on the 2 million acre lease.

The concession covers an area beyond the 3-mile limit, and lies off

the east and southeast coasts of the island. It extends northward from the international boundary between Venezuela and Trinidad. Water depths are in the 50-ft. to 250-ft. range over much of the concession, and are said not to exceed 600-ft. anywhere on the block.

No bonus was paid for the concession, which runs for 10 years with a 5-year extension optional if commercial production is established. A 50-50 profit division has been agreed upon. Trinidad will also collect a 1/8 royalty.

The three-company group must perform a work obligation of approximately one-half million during the first year, and about $1 million per year thereafter. A small rental, plus surrender obligations of some of the acreage, is also stipulated.



DOWN IN THE PERSIAN GULF is Aramco's drilling barge "Queen Mary," which sank in 45-ft. of water near Safaniya Well No. 39 on December 20.

Sinking Of The Drill Barge "Queen Mary"

Bow anchor piling failed, and vessel swung broadside to high wind and waves and swamped

Arabian American Oil Company's drilling barge **Queen Mary** sank in approximately 45-ft. of water at 5:45 a.m., Dec. 20 near Safaniya Well No. 39, 22 nautical miles out in the Persian Gulf from Safaniya, according to the Aramco **Sun and Flare.**

No one was injured in the accident. The stern of the vessel rested on the bottom while the bow was kept afloat by air tanks.

The barge sank after the port bow piling failed, allowing it to swing around broadside to strong winds and high waves which swamped the vessel before corrective measures could be taken.

The **Queen Mary,** which carries a 12-man crew, had been subjected to south winds of about 40 knots and relatively high swells during the evening. Shortly after midnight, the wind shifted suddenly and the sea turbulence increased to swells estimated at 12-ft. to 15-ft. high.

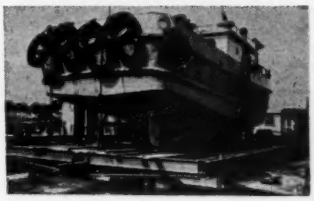
At 4:30 a.m. the port bow anchor failed, but the barge was held in position by the mud and water pipelines and the electric cables connected to the drilling platform approximately 20-ft. away. When these connnections snapped, the barge swung east where it was held by the remaining anchors.

A heavy wave broke over the side, smashing in the rolling doors in the engine and pump house areas and floating out the electric-driven bilge pumps. The crew attempted to cut the anchors loose from the stern to let the barge swing freely into the wind, but the water was washing over the deck with such force they couldn't work without being washed overboard.

The crew next attempted to slack off on the forward starboard anchor winch, but the main engines drowned and all power was lost. The stern then began settling into the water, and the crew abandoned the barge at 5:45 a.m. after making every effort to save it.

A study was begun immediately to determine the feasibility of salvaging and repairing the vessel.

The derrick barge **Squalo,** owned by MICOPERI, S.p.a. of Milano, Italy, was brought from Khorramshar, and the drilling barge was subsequently refloated in just three working days—a highly successful salvage operation.



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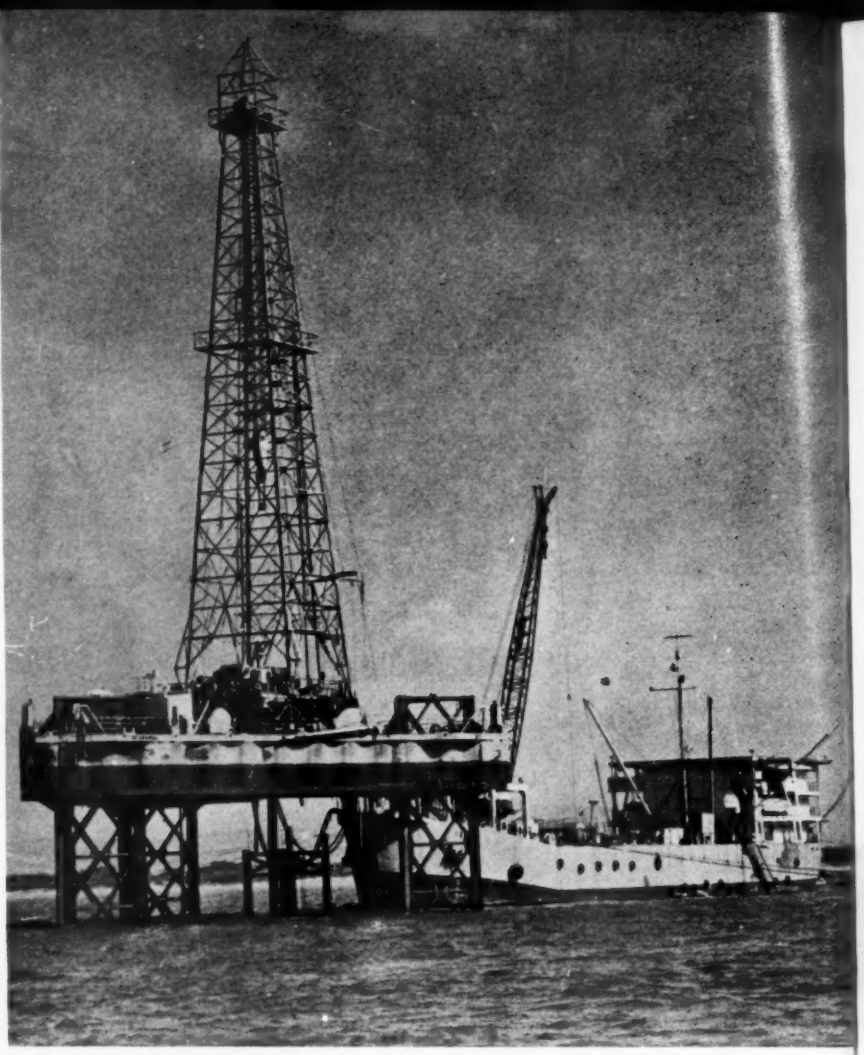

SHOWN ON LOCATION OFF SICILY, the mobile drilling platform SCARABEO is being towed to the Gulf of Suez, where it will drill an offshore wildcat for Cie. Orientale des Petroles in the vicinity of Belayim Bay.

TO DRILL IN GULF OF SUEZ

MOBILE UNIT "SCARABEO" TOWED FROM ITALY

An offshore wildcat will be spudded in soon by the mobile drilling unit **Scarabeo** in the Gulf of Suez. The location, off the Sinai Peninsula at Belayim Bay, will test a structure believed to be an offshore extension of the onshore Belayim field.

The drillsite will be a few miles off Belayim Bay, on acreage held by Cie. Orientale des Petroles (COPE). This is the company owned by International Egyptian, which is controlled by Italy's ENI and Petrofina, and by Egypt. International Egyptian owns 51 percent of the company, and Egypt controls 49 percent.

Cie. Orientale des Petroles now produces some 300,000 bpd from onshore fields from Abu Redeis and Belayim fields.

Drilling contractor on the job is SAIPEM, subsidiary of ENI. For the test, the company has towed its mobile drilling platform **Scarabeo** from Italy to the Gulf of Suez.

Built in the U.S., the platform was first towed to Gela, Sicily, where it brought in Europe's first offshore well (see Offshore, Aug. 25, 1959, p. 41). It was supported during this drilling operation by the 5,000-ton drilling tender **Saipem.**

The small portable drilling platform, built at a cost of $1 million, is equipped to drill below 10,000-ft.

Winser Elected V-P Of Southern Marine & Aviation Underwriters

Brown named Pacific Coast manager for New Orleans firm, will head Los Angeles office

C. Anthony Winser has been elected a vice president of Southern Marine & Aviation Underwriters, Inc., of New Orleans. The announcement was made by L. K. Giffin, the firm's president, who simultaneously announced the establishment of offices in San Francisco and Los Angeles.

Winser was one of the founders and served as first president of International Aviation Underwriters, Inc. Prior to this affiliation with IAU, he was a vice president of Aero Associates, Inc., managing the eleven Pacific states. Prior to that, he was associated with Cravens, Dargen and Co., and during World War II served in the Naval Reserve and was assigned to Pan American World Airways as a pilot on transpacific Navy Contract runs.

Winser, long recognized as an authority on aviation underwriting, compiled the first comprehensive guide ever published on underwriting factors relating to agricultural aviation. He has also correlated statistical data of the Civil Aeronautics Administration and the Civil Aeronautic Board from 1946 for background information in aviation underwriting—probably the broadest base established up to this time.

Winser will make his headquarters at the Russ Building in San Francisco.

William W. Brown has been named Pacific Coast manager for Southern Marine & Aviation Underwriters, heading the staff at the firm's new Los Angeles office at 2975 Wilshire Blvd.

Brown served in World War II as a Navy pilot, and is a graduate of the University of Southern California with a degree in business administration. He has spent the intervening years in the insurance industry, starting with the Royal-Liverpool Group in 1948. He joined Aero Associates in 1953 and became associated with Hansen & Rowland as London correspondent and aviation manager in 1957. In 1959 he established the Los Angeles office of International Aviation Underwriters, Inc., and became vice president.

ADVISORY COMMITTEE of the Gulf Coast School of Drilling Practices, which opens in April at Lafayette, La. consists of (seated, left to right): committee chairman Carl A. Kinney, drilling superintendent, The Atlantic Refining Company, Lafayette; school coordinator Dr. G. G. Varvaro, professor and head of the Department of Petroleum Engineering, University of Southwestern Louisiana, Lafayette; and committeeman W. C. Fatjo, owner, W. C. Fatjo Drilling Company, Lafayette. Other committee members, standing, left to right, are Keith Lindley, district manager, Sunray Mid-Continent Oil Company, Lafayette; Kirby Simmons, vice president, Nicklos Drilling Company, Eunice; Harvey Fitzpatrick, drilling engineer, The California Company, Lafayette; and W. A. (Stud) Grapes, president and general manager, Gradome Drilling Company, Lafayette.

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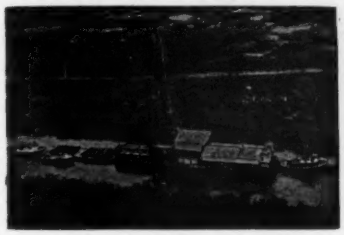

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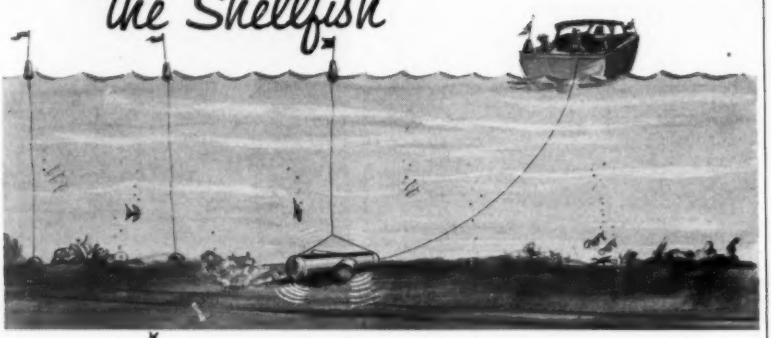

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R. H. Rainey Promoted By Geophysical Service Inc.

Appointment of R. H. Rainey as assistant to C. M. Moore, Jr., eastern hemisphere vice president, has been announced by R. C. Dunlap, Jr., president of Geophysical Service Inc., the exploration subsidiary of Texas Instruments Incorporated.

Rainey has been with GSI for 14 years. Four and a half years of his geophysical experience was gained as a supervisor and later manager of GSI reflection, refraction and gravity operations in the Far East. In addition, he has worked as a seismic supervisor in Canada and West Texas. He was made marketing manager in 1959 and held that post at the time of his new appointment.

Head & Guild Equipment Corp. Promotes Otting

Donald V. Otting has been named vice president of Head & Guild Equipment Corp., 5611 Navigation, distributors of Lorain cranes, shovels, back hoe and clamshell equipment, it has been announced by Frank Head, president.

Otting has been with the firm for two years, having joined the com-

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pany after eight years as sales engineer with Horton & Horton, Houston. He is a graduate of The University of Texas, and served as a paratrooper in the army.

Otting is charged with the development of sales and rental of both new and reconditioned equipment. His promotion is part of a general expansion program which includes enlargement of the sales and rental departments of the firm and an extension of the company's service territory to include the entire south.

In addition to standard earth-moving equipment, Head & Guild Equipment Corp. also serves the offshore drilling industry by supplying cranes especially designed for offshore drilling rigs.

Otting

Armstrong

Turner Armstrong Named Halliburton Vice President

Turner Armstrong has been named vice president of Halliburton Company in charge of the Welex division. His election to the new post follows Welex's merger into Halliburton, from a wholly owned but independently managed subsidiary corporation to an operating division.

Armstrong joined Halliburton in 1940, after graduating from the University of Oklahoma with a B.S. degree in electrical engineering, and has since worked in Mid-Continent and California operations. Most recently he was a vice president of the Welex subsidiary, until its merger with Halliburton.

The Halliburton vice president will be based at Houston, which will be headquarters for Welex.

Goldston Appointed To Board Of Tex-Tube, Inc.

Appointment of W. J. Goldston, prominent Houston oilman and businessman, to the board of directors of Tex-Tube, Inc. has been announced by president Charles A. Carter.

Goldston is president of Goldston Oil Corp. and Goldrus Drilling Co. He is a director of the First City National Bank of Houston and of the Movible Offshore Company, Houston. He is a former president of the Mid-Continent Oil and Gas Association.

A graduate of Oklahoma University, Goldston was a geologist with Gulf Oil Corp. from 1929 until 1931, when he entered the oil business.

Tex-Tube, Inc. is a Houston producer of steel tubular goods, with 1959 sales of $18,118,576.00. The company recently opened a new high-speed pipe mill that has been termed the most modern pipe mill in America.

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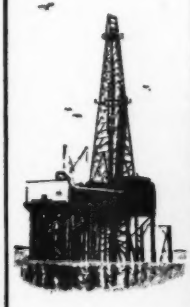

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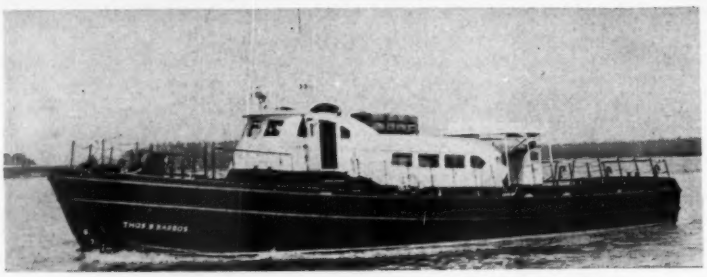

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Robertson, Reed Given New Posts By Magcobar

Promotion of A. T. Robertson from personnel director to the newly created position of director of industrial relations of Magnet Cove Barium Corporation (Magcobar), has been announced.

Kenneth D. Reed, formerly manager, employment and employee benefits, has been appointed to the newly created position of assistant director of industrial relations.

Robertson was graduated from Baylor University with a B.B.A. degree in 1950. He worked for Humble Oil and Refining Company in a sales capacity for one year, joining Magcobar in 1952.

Reed was graduated from North Texas State College in 1955 with a B.B.A. degree in personnel management. Following two years as a claims adjuster, he became associated with Magcobar as employment supervisor.

Letters to the Editor

Dear Sir:

We refer to your article on page 24 of the October 1960 issue entitled "The Offshore Company Buys Two More Drill Barges" which reads (in part) as follows:

"The Offshore Company has also been given exclusive license to the DeLong jacking mechanisms, used on drill barges and similar structures, and to platforms and structures utilizing DeLong patented designs and inventions."

We believe this article seriously misrepresents the position of The Offshore Company and DeLong Corporation since, in essence, The Offshore Company is the exclusive licensee of DeLong Corporation only in the Gulf of Mexico area for all purposes; the exclusive licensee of DeLong Corporation throughout the world excluding the coast of California solely for mobile drilling platforms; and most important, only a non-exclusive licensee of DeLong Corporation, throughout the world, excluding specified territorial areas, for all other purposes.

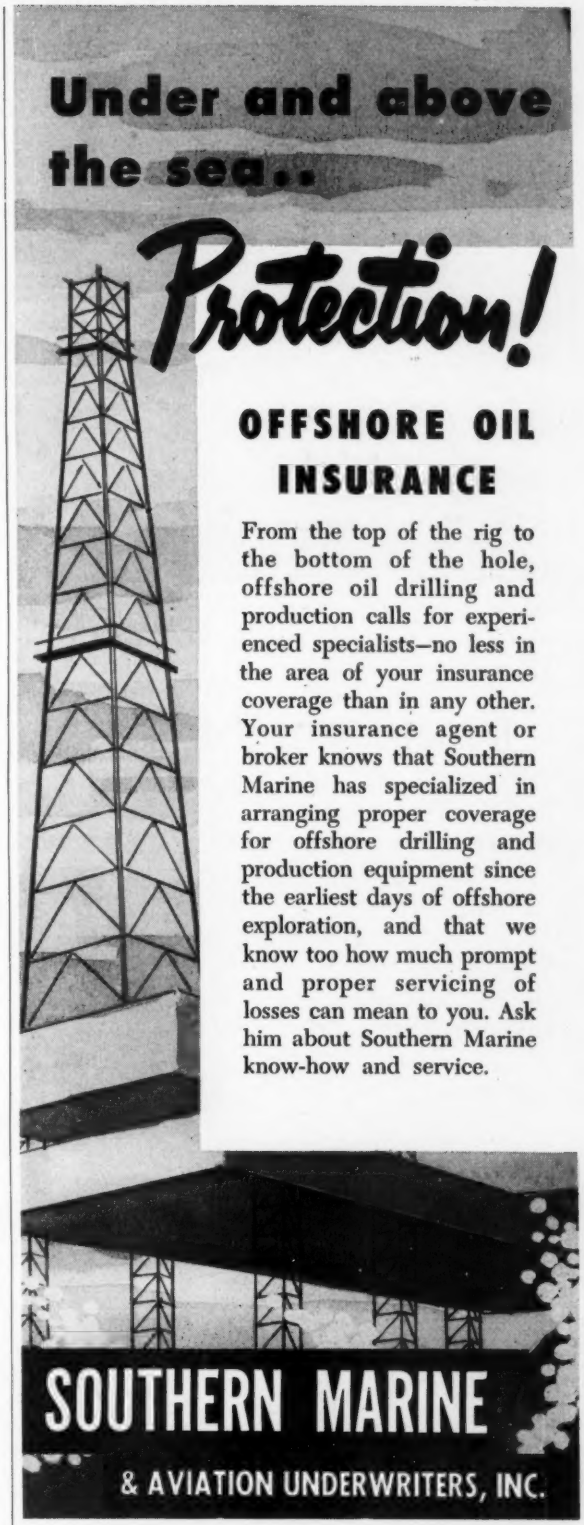
Since the DeLong method is utilized for many other construction and marine purposes other than offshore mobile drilling platforms, we (would like for you to so) clarify the statement made in the October issue.

Very truly yours,
DE LONG CORPORATION
Edward A. Fey
Vice President

Mobile Units, Tenders, And Self-Contained Platforms

Mobile Units

OWNER	NAME	WATER DEPTH	PRESENT STATUS
Barge Facilities, Inc. Twin-hull submersible 217' x 100'	S-66	100'	Drilling for Calco, Noble Drilling Co., Bay Marchand, La.
Barnwell Offshore, Inc. Self-elevating 176' x 176' x 152' with three 175' legs	"Mister Cap"	to 125'	Working for C.A.T.C. on Well No. 2, Block No. 40, Grand Isle Area
Barnwell Offshore, Inc.	Rig No. 2		Moved onshore to workover land wells temporarily.
Blue Water Drilling Corp. Submersible	Rig No. 1	60'	Drilling for Shell Oil Co., Block 139, Ship Shoal Area
The California Company Submersible 11' x 90' x 156' with four 3' x 10' x 35' pontoons	S-45	25'	Ship Shoal Area, 107
The California Company Submersible 12' x 90' x 190', with four 4' x 24' x 50' pontoons	S-55	45'	Bay Marchand, La., Noble Drilling Co.
Continental Marine Exploration Co. Submersible 230' x 99' with 54' between fixed hulls	"M & H Drilling Platform No. 12"	to 30'	In Galveston, Texas for repairs
Coral Drilling Company Submersible 180' x 151' x 84' with four pontoons	"Mr. Arthur"	to 70'	Drilling for Tennessee Gas & Oil Co., Block 180, West Cameron Area
Deepwater Exploration Co. Self-elevating overall 121' x 118'	"Deepwater No. 2"		Sold for scrap
Delta Marine Drilling Co. Submersible	"Chris Zeppa"	to 35'	Drilling for Shell Oil Co., Block 100, Engene Island Area, St. Mary Parish
Dixilyn Drilling Corp. Self-elevating 194' x 152' overall. Three 175' legs	"Julie Ann"	to 105'	Drilling for Tennessee Gas & Oil Co., Block 173, West Cameron Area
Global Marine Exploration Co. Floating vessel	Cuss I		Scheduled to drill off Guadalupe Island in 12,000-ft. water
Global Marine Exploration Co. Floating vessel	SM-1		Idle
Global Marine Exploration Co. Floating vessel	Submarex		Idle—Lake Michigan
Gulf Marine Drilling, Inc. Submersible	Rig No. 1	35'	Drilling for Gulf Oil Corp., Block 24, West Delta, Well No. 1
Hyperion Constructors Self-elevating	"George F. Ferris"	200'	Los Angeles, Calif., Stacked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OWNER	NAME	WATER DEPTH	PRESENT STATUS
Kerr-McGee Oil Ind., Inc. Submersible 13′ x 54′ x 160′ with two 13′ x 14′ x 110′ pontoons	Rig 40	to 22′	Drilling for Kerr-McGee, et al, Block 28, Ship Shoal Area
Kerr-McGee Oil Ind., Inc. Submersible 13½′ x 72′ x 140′ with two 13½′ x 13½′ x 140′ pontoons	Rig 44	to 40′	Drilling for Shell Oil Co., Block 27, South Pass Area
Kerr-McGee Oil Ind., Inc. Submersible 142′ x 69′ x 13′6″, with two 10′ x 11′ x 145′ pontoons	Rig 45		Drilling for Superior Oil Co., Block 71, Vermilion Area
Kerr-McGee Oil Ind., Inc. Submersible	Rig 46	to 70′	Drilling for Mobil Oil Co., Block 7289, West Cameron Area
Kerr-McGee Oil Ind., Inc. Submersible	Rig 47	to 70′	Drilling for Gulf Oil Corp., Block 21, South Tambalier Area
Long Point Gas & Oil Ltd.	Translake No. 1	35′	Drilling for Self, Lake Erie
Long Point Gas & Oil Ltd.	Translake No. 2	40′	Drilling for Self, Lake Erie
Louisiana-Delta Offshore Corp. Submersible 180′ x 151′ x 12′	Drill Barge Louisiana	to 65′	Drilling for Humble Oil Co. and Shell Oil Co., Block 30, West Delta Area
Louisiana-Delta Offshore Corp. Submersible 156′ x 90′	Drill Barge Delta	to 25′	Main Pass Area, Block 45
Mobil Oil Co.	Rig 52	24′	Sold
Midcon Oil & Gas Co., Ltd. Cable tool	Midcon No. 1	90′	Drilling for self, Lake Erie
Movible Offshore Co. Submersible 201′ x 211′ x 110′	"Movible No. 2"	to 80′	Drilling for Shell Oil Co. Block 27, South Pass Area
Movible Offshore Co. Submersible 200′ x 146′ x 67′	"Movible No. 3"	to 45′	Drilling for Mobil Oil Co., Block 110, West Cameron Area
Movible Offshore Co. Self-Propelled Drilling Tender	Rig No. 4		Drilling for Mobil Oil Co., Block 131, Vermilion Area
N. V. Nederlandse Ardolie	"Triton"		Outfitting in Cardiff, Wales for location in North Sea
Ocean Drilling & Exploration Company Submersible 200′ x 300′ x 98′	"El Dorado"	to 70′	Drilling for Odeco et al, Block 129, Eugene Island Area
Ocean Drilling & Exploration Company Submersible 132′ x 220′ x 58′	"Mr. Charlie"	40′	Drilling for Odeco, et al, Bock 19, South Pelto Area
Ocean Drilling & Exploration Company Submersible 120′ x 180′ x 49′	"John Hayward"	30′	Drilling for Odeco, et al, Block 89, Eugene Island Area

OWNER	NAME	WATER DEPTH	PRESENT STATUS
Ocean Drilling & Exploration Company Submersible 200' x 300' x 93'	"Margaret"	to 60'	Drilling for Shell Oil Co., Block 30, West Delta Area
Ocean Drilling & Exploration Company Submersible 120' x 180' x 50'	"St. Louis"	30'	Drilling for Shell Oil Co., Block 100, Eugene Island Area
The Offshore Company Self-elevating 131/2' x 117' x 220' with fourteen 6' dia. caissons	Mobile Unit No. 52	100'	Drilling for Petroleum Leaseholds, Inc., Block 194, Eugene Island Area
The Offshore Company Submersible 12' x 74' x 200' with four 6' dia. caissons	Mobile Unit No. 53	35'	Drilling for Phillips Petroleum Co., Block 118, West Cameron Area
The Offshore Company Self-elevating 200' x 104' x 15' with eight 12' dia. towers	Mobile Unit No. 54	100'	Drilling for Phillips Petroleum Co., Block 115, Vermilion Area.
The Offshore Company Self-elevating 200' x 104' x 15' with eight 12' dia. towers	Mobile Unit No. 55	100'	Drilling for Paria Operations, Gulf of Paria, Venezuela.
The Offshore Company Self-elevating 200' x 104' x 15' with eight 12' dia. towers	Mobile Unit No. 56	100'	Leased to Pan-American International Persian Gulf
The Offshore Company Self-elevating 188' x 106' x 13' with four 10' dia. caissons	Mobile Unit No. 57	80'	Leased to Texaco-Trinidad Gulf of Paria
Offshore International S.A. Self-elevating 200' x 104' with 8-12' dia. towers	Delong No. 144	126'	Drilling for Pan American International in Persian Gulf.
Penrod Drilling Company Submersible 196' x 108'	Rig 50	35'	Drilling for Hunt Oil Co. Offshore Lafouche Parish
Penrod Drilling Company Submersible 150' x 190'	Rig 51	to 60'	Drilling for Calco, Bay Marchand Area
Penrod Drilling Company Submersible 198' x 174'	Rig 52	100'	Drilling for Pan American Petroleum Corp., Block 389, Offshore Texas
Place Gas & Oil Co., Ltd.	Mr. Cliff	42'	Drilling for self, Lake Erie
Place Gas & Oil Co., Ltd.	Barge 2		Drilling for Self, Lake Erie
Place Gas & Oil Co., Ltd.	Barge 3		Drilling for Self, Lake Erie
Place Gas & Oil Co., Ltd.	"Mr. Pat"		Drilling for Self, Lake Erie
Reading & Bates Offshore Drilling Company Self-elevating	"C. E. Thornton"	to 110'	Drilling for Japanese Arabian Oil Co. in Persian Gulf
Reading & Bates Exploration Company Self-elevating	"Mr. Louie"	To 120'	Drilling for Pure Oil Co., Block 209, Ship Shoal Area
Rimrock Tidelands, Inc. Submersible	"Rimtide"	35'	Drilling for California Co., St. Lse. 1367, Bay Marchand Area
Sea Drilling Corp. Submersible	"Seadrill 2"	30'	Block 26, West Cameron Area
Sea Drilling Corp. Submersible	"Seadrill 3"	30'	Block 26, West Delta Area
The Shell Co. of Qatar, Ltd.	Seashell	100'	Drilling for Shell off Qatar

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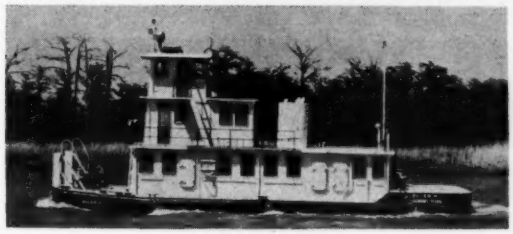

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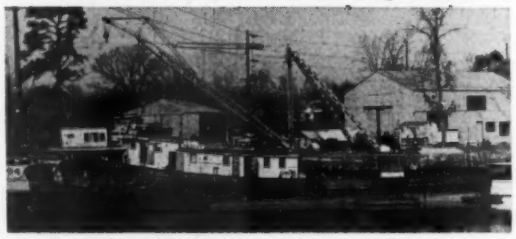

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OWNER	NAME	WATER DEPTH	PRESENT STATUS
Southeastern Drilling Corp. Submersible 11′ x 90′ x 156′ with four pontoons	Southeastern-45		Drilling for the California Co., Ship Shoal Block 107
Standard Oil Co. of Calif.	Western Explorer	200′	California, stacked
Tidelands Drilling Co. Self-elevating Deck 258′ x 104′, pad 200′ x 180′ with four 10′ dia. columns	"Mr. Gus II"	150′	Drilling for Texaco, Inc., in South Pass Area, Block 37
Union Producing Co. Submersible 160′ x 190′	Barge A	to 70′	Drilling in Block 186, Ship Shoal Area
Zapata Off-Shore Company Self-elevating. 194′ x 152′ overall. Three 145′ legs	"Vinegar-roon"	to 105′	Drilling off Galveston, Federal Block 293
Zapata Off-Shore Company Self-elevating. 20′ x 80′ x 140′, with three 152′ triangular legs	"Scorpion"	80′	Drilling in Block 86, Vermilion Area
Zapata Off-Shore Co. Floating drill barge	"Nola 1"		Drilling in the Gulf of Paria, Trinidad
Zapata Off-Shore Co. Floating drill barge	"Nola 3"		Drilling off Florida, SI. 1011 —Well No. 2.

Drilling Tenders

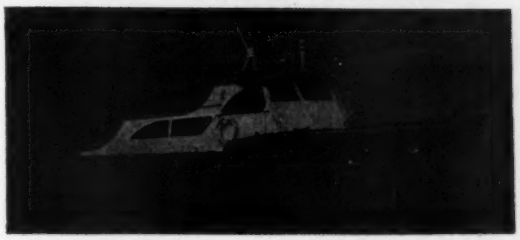
An-Son Offshore Drilling Co.	"Carl B. Anderson"		Idle
The California Company Converted LST, 328′ x 50′	S-21	25′	Bay Marchand, Louisiana, Noble Drilling Co.
The California Company Converted LST, 328′ x 50′	S-22	49′	Bay Marchand, Louisiana, Loffland Bros.
The California Company Converted LST, 328′ x 50′	S-23		Mothballed
The California Company LST, 328′ x 50′	S-24	46′	Bay Marchand, Louisiana, Noble Drilling Co.
The California Company LST, 328′ x 50′	S-25	48′	Bay Marchand, Louisiana, Loffland Bros
The California Company LST, 328′ x 50′	S-26	40′	Noble Drilling Co., Bay Marchand, La.
CATC Group New tender, 260′ x 54′	"J. C. Craig"	86′	Grand Isle, Block 47
CATC Group New tender, 260′ x 54′	"Carle Sharp"	50′	East Cameron, Block 48
CATC Group New tender, 260′ x 54′	"Ernie Miller"	146′	West Delta, Block 71
CATC Group New tender, 260′ x 54′	"Jack Cleverley"	94′	Eugene Island, Block 208
Deepwater Exploration Co. Converted LST, 328′ x 50′	"Deepwater No. 1"		In shipyard for annual dry-docking, overhaul and refurbishing
Delta Marine Drilling Co. Converted LST, 326′ x 50′	"Joseph Zeppa"		West Delta, Louisiana, Block No. 30, Humble Oil & Refining Co.
Gulf Oil Corporation New tender	"Dolphin"		Completely placed in moth ball fleet at Orange, Tex., engines pickled, and rig stacked
Gulf Oil Corporation Converted LST, 328′ x 50′	"Eagle"		Rig stacked at Morgan City, Louisiana
Gulf Oil Corporation New tender, 272′ x 60′	"Pelican"		Block 132, S. Timbalier area, self
Humble Oil & Refining Co. Converted LST, 328′ x 50′	ST-1		Standing by
Humble Oil & Refining Co. Converted LST, 328′ x 50′	ST-2		Standing by
Humble Oil & Refining Co. Converted LST, 328′ x 50′	ST-3		Standing by
Humble Oil & Refining Co. Converted LST, 328′ x 50′	ST-4		Standing by
Humble Oil & Refining Co. Converted LST, 328′ x 50′	ST-5		At Orange, Texas for storage
Humble Oil & Refining Co. Converted LST, 328′ x 50′	ST-6		Standing by
Humble Oil & Refining Co. Converted LST, 328′ x 50′	ST-7		Standing by
Humble Oil & Refining Co. Converted LST, 328′ x 50′	ST-8		Standing by

OWNER	NAME	WATER DEPTH	PRESENT STATUS
Humble Oil & Refining Co. Converted LST, 328' x 50'	ST-9		Standing by
Humble Oil & Refining Co. Converted LST, 328' x 50'	ST-10		Standing by
Humble Oil & Refining Co. Converted LST, 328' x 50'	ST-11		Standing by
Humble Oil & Refining Co. Converted LST, 328' x 50'	ST-12		"Q" Platform in West Delta, Block 30 field
Kerr-McGee Oil Ind. Inc. New Tender, 250' x 50'	"Kermac II" Rig 43		Idle
Kerr-McGee Oil Ind. Inc. New Tender, 250' x 50'	"Kermac III" Rig 48		Drilling for Gulf Oil Corp., Block 154, Ship Shoal
Kerr-McGee Oil Ind., Inc. Converted YF, 260' x 48'	"Frank Phillips" Rig 39		Idle
Magnolia Petroleum Co. Converted YF	"Gulf Coast Barge No. 2"		Out of Service
MCN Group Converted YF	MDT-1		Drilling in Block 119, Eugene Island Area, Well P-2 for self
MCN Group Converted YF	MDT-2		Out of Service
MCN Group Converted YF	MDT-3		Out of Service
MCN Group Converted YF	MDT-4		Out of Service
MCN Group Converted YF	MDT-7		Out of service
Pan American International Oil Company	Panintoil 1	143'	Drilling for self in Persian Gulf
Reading & Bates Offshore Drilling Company	"J. W. Bates"		Drilling in Persian Gulf for Japanese Arabian Oil Co.
Reading & Bates Offshore Drilling Company	"George M. Reading"		Drilling for Gulf Oil Corp., Block 48, South Marsh Island Area
Reading & Bates Exploration Drilling Company	"G. L. Temple"		Drilling for Tennessee Gas & Oil, Block 215, Eugene Island Area
Reading & Bates Offshore Drilling Corp.	"J. W. Nickle"		Drilling for Tennessee Gas & Oil Co., Block 180 A, West Cameron Area
Southeastern Drilling Corp. Converted YF	Rig 12 Barge 9		Persian Gulf for the Arabian Oil Co., Ltd.

Self-Contained Platforms

COMPANY	DESCRIPTION	YEAR BUILT	LOCATION	WATER DEPTH
Freeport Sulphur Co.			Block 9, Grand Isle, Self	45'
Gulf Marine Drilling, Inc. Rig #2			Bayou Boeuf, awaiting location	
Gulf Oil Corporation	40' x 100'	1957	Rig Stacked at Morgan City, La.	
Humble Oil & Refg. Co. Rig #50	78' x 200'	1956	Block 16 Field, "L" Platform, Grand Isle Area	50'
Humble Oil & Refg. Co. Rig #54		1958	"O" Platform, West Delta Block 30 field	
Humble Oil & Refg. Co. Rig #55			"P" Platform, Grand Isle Block 16 field	
J. Ray McDermott			Block 33 West Cameron Area, Kerr McGee Oil Industries, Inc.	
Phillips Petroleum Co.	88'9" x 140'	1956	Block 191, Eugene Island Area, platform inactive	81'
The Pure Oil Co. Converted LST	328' x 50'	1958	Orange, Texas	
The Superior Oil Co.	96' x 225'		Block 168, West Cameron Area	

FINER EQUIPMENT—



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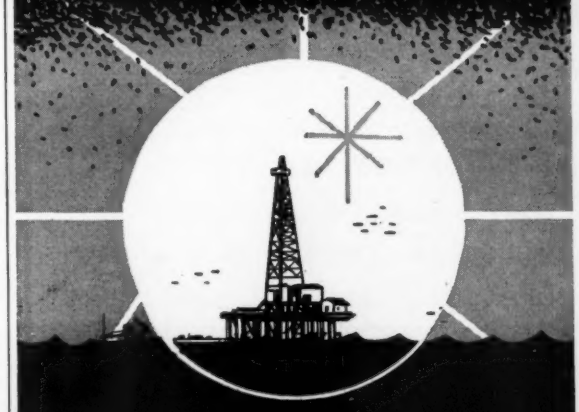

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The Slush Pit . . .

A none-too-modest nimrod, on a hunting trip, took aim and fired. But to his amazement the bird sailed on undisturbed. The marksman watched in a dazed silence, then dashed his gun to the ground and shouted: "Fly on, you blankety-blank fool! Fly on with your gol-durned heart shot out."

"Smith got the promotion over me," the toolpusher sadly announced to his wife. "Guess the boss thinks I'm not in his class."

"Of course you're in his class," snapped his wife. "He's nothing but a stupid moron!"

As they had planned to drive across country on their honeymoon, the intended bride thought it would be helpful if she learned to drive so as to be able to spell her husband on the long trip. She managed to take a course of driving lessons and at last, just before the wedding, was awarded a learner's driving permit.

The wedding went off in style and after the home reception the happy couple drove off in a cloud of rice and old shoes. The members of the wedding party were astonished a few moments later when the bride reappeared at the house, blushing with confusion.

"Goodness," she gasped, "I forgot my beginner's permit!"

A woman with a past attracts men who hope history will repeat itself.

"I heard you advertised for a wife. Any replies
"Yes, hundreds."
"Good! What did they say?"
"Oh, they all said, 'You can have mine'."

Two golf opponents reached the eighteenth green even up. One had only to sink a tricky 10 foot putt to win. He lined up the putt, pulled back for the stroke when a sudden noise stayed his hand. A funeral cortege was passing by.

The golfer snapped to attention, whipped off his hat, held it over his heart until the last car disappeared. Then he calmly sank his putt.

"Congratulations," said his opponent grudgingly. "It took iron nerve not to let that funeral procession fluster you into missing your putt."

"It wasn't easy, admitted the victor. "On Saturday, we would have been married 25 years."

"I know this is our honeymoon, darling, but I have to keep up with what's happening offshore."

first true two-pump cementer has independent mechanical cement mixer

Until now, "two pump" cementers have had only one pump available to pump and displace slurry while cement was being mixed. The second pump was needed for mixing.

The new Dowell double-pump cementing unit has changed that. It features an *independent mechanical cement mixer* which does not depend on either of the two triplex pumps for operation. This mixer is driven by either one or both of two auxiliary hydraulic pumps — one mounted on each diesel engine. An additional pump supplies water to the mechanical blender. Thus, both high-pressure triplex pumps are free to pump and displace slurry during the entire job — from start to finish.

These pumps can be used together or independently. During a squeeze job, for example, the mechanical mixer can blend cement, water and admixtures while one pump is pumping and displacing slurry and the second pump is holding pressure on the casing. The triplex pumps can be operated at the same rate or at different rates. They also can be started and stopped together or independently, an important advantage when cementing multiple strings of tubing.

This truly double-pump system, with its "Controlled Slurry" mechanical mixer . . . the Densitometer, used to control slurry densities and provide an accurate, permanent record of slurry weights . . . the Dowell air-operated bulk cement transport, which permits any number of transports to be unloaded through a single surge hopper . . . and experienced Dowell cementing personnel are your assurance of first-class cementing by Dowell. Dowell, Tulsa 1, Oklahoma.

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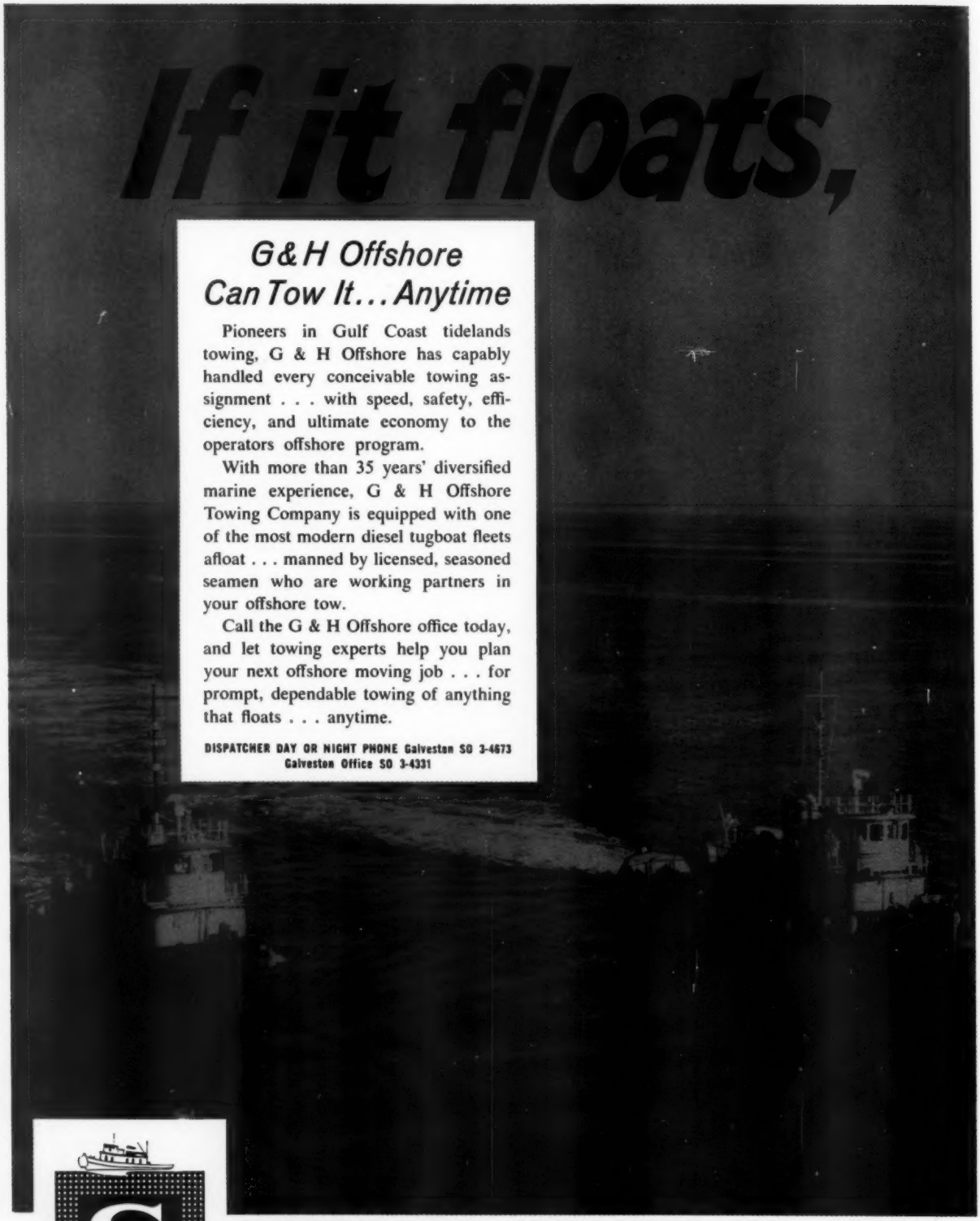

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